Chapter 7B: Update on RECOVER Implementation and Monitoring for the Comprehensive Everglades Restoration Plan

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SUMMARY

This chapter provides a very brief update on Restoration Coordination and Verification (RECOVER) team activities documented in Chapter 7B of the *2007 South Florida Environmental Report – Volume I* (SFER). Future SFER chapters on RECOVER are not expected to contain updates on planning efforts; they will provide summaries of RECOVER products. Additional information on RECOVER is available at www.evergladesplan.org/pm/recover/recover.cfm.

The remainder of this chapter provides a summary of the *2007 System Status Report* (RECOVER, 2007). This report provides an analysis of monitoring data from the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan (MAP), and other sources, and provides preliminary assessments of ecological condition and status of the South Florida ecosystem. Summaries of assessments for several indicators from each of the four modules (Southern Estuaries, Northern Estuaries, Greater Everglades, and Lake Okeechobee) are provided in this chapter. Also, lessons learned during development of the *2007 System Status Report* are summarized.

LAKE OKEECHOBEE MODULE

The Lake Okeechobee Module section summarizes assessments of lake stage, submerged aquatic vegetation (SAV), and littoral zone vegetation presented in the *2007 System Status Report* (RECOVER, 2007). The lake has experienced an increased frequency of high lake stages due to hurricanes in 2004 and 2005. The hurricanes also caused poor light conditions due to increased turbidity resulting from resuspension of bottom sediments and wind and wave-induced uprooting of submerged and emergent vegetation. Large decreases in SAV have been noted since 2004. SAV areal coverage was 54,875 acres (ac) in late summer 2004. Coverage was reduced to 10,872 ac in late summer 2005 and further reduced to 2,965 ac in late summer 2006. Average SAV biomass declined from 32.3 to 4.7 grams dry weight per square meter (g dry wt m^{-2}). Coverage of bulrush, a littoral zone plant, varied from 193 to 285 ac during the period from 1999 to 2005. In 2003, the lake's littoral zone had many acres of exotic/nuisance plant species: cattail covered

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23,840 ac, torpedograss covered more than 17,000 ac, and fragrant water lily covered nearly 11,000 ac.

NORTHERN ESTUARIES MODULE

The Northern Estuaries Module section summarizes findings for SAV and oysters presented in the *2007 System Status Report* (RECOVER, 2007). Southern Indian River Lagoon and St. Lucie Estuary have 19,799 ac of potential seagrass habitat, but less than 50 percent is presently covered by seagrass. Seagrass in this area appears to have remained fairly stable from 1999 through 2003, then declined dramatically following the 2004 and 2005 hurricanes and associated Lake Okeechobee discharges. In 2001, portions of Lake Worth Lagoon that are expected to be affected by CERP implementation had SAV coverage of 492 ac out of 1,265 ac of potential suitable habitat. Dramatic decreases were seen in seagrass cover within the Loxahatchee River Estuary following the 2004 hurricane season. Oyster surveys were performed in 2004 and 2005 to determine current oyster reef locations and acreages within the Northern Estuaries. Caloosahatchee Estuary has 18 ac of live oyster bars, St. Lucie Estuary has 117 ac, Loxahatchee River Estuary has 10 ac, and Lake Worth Lagoon has approximately 18 acres.

GREATER EVERGLADES WETLANDS MODULE

The Greater Everglades Wetland Module section summarizes key findings from the *2007 System Status Report* (RECOVER, 2007) that indicate how wading birds may have responded to prey populations and water conditions during June 1, 2005–May 31, 2006 (2006 nesting season). Hydrologic conditions across the Everglades during the 2005 wet season (June 1, 2005–October 31, 2005) and 2006 dry season (November 1, 2005–May 31, 2006) supported a successful year for wading bird nesting throughout much of the system. Ample foraging patches were available for fledging birds late in the nesting season and, overall, the 2006 nesting season was successful for wading birds in terms of overall nest numbers. Nesting success was unusually high for all wading bird species, and few abandoned colonies were noted. Wading bird colony locations and nest numbers during the 2006 season were concentrated in the Water Conservation Areas (WCAs) and Lake Okeechobee’s littoral zone where fish biomass was moderate to high during the previous wet season. Wading birds had lower nesting in southern Everglades National Park (ENP or Park) where marsh fish standing crop was depressed during the previous wet season. High crayfish biomass in the western ENP did not support extensive wading bird nesting in the southern Everglades, as only small numbers of all wading bird species nested near the region of high crayfish biomass. The 2006 Florida Bay roseate spoonbill (*Ajaia ajaja*) nesting season also had a strong response to hydrologic and prey conditions prior to and during the nesting season. The three watersheds used by roseate spoonbills for nesting in northeast Florida Bay indicated a temporal sequence in peak prey availability across the landscape that was conducive to spoonbill nesting success during 2006. Sequential drying across the landscape that occurred in coastal wetlands above northeast Florida Bay was conducive to high spoonbill nesting success despite a low number of nests in that subregion during 2006.

SOUTHERN ESTUARIES MODULE

The Southern Estuaries Module section summarizes environmental health of Biscayne and Florida Bays based on chlorophyll *a*, salinity and SAV as presented in the *2007 System Status Report* (RECOVER, 2007). Overall, distribution of chlorophyll *a* concentrations was low in the Southern Estuaries, with highest concentrations consistently measured along the southwest Florida coast. During low salinity, the area of elevated chlorophyll expanded. Average wet and dry season salinity from June 1, 2005–May 31, 2006, was 23 and 28 parts per thousand, respectively. As expected, lower salinities were measured closer to shore and highest salinities were located offshore. SAV within regions that have had increasing light availability and salinity, and decreasing nutrients, has been increasing in both concentration and occurrence. Regions in which light availability decreased due to substantial increases in both turbidity and chlorophyll *a* levels had sparse and less diverse SAV populations.

UPDATE ON RECOVER ACTIVITIES

RECOVER continues its primary function of assessing the ecological health of the South Florida ecosystem as a precursor to measuring the effects of CERP and other restoration activities as projects are implemented. In addition, it continues to better integrate the set of systemwide performance measures and interim goals and targets (RECOVER, 2005), reconcile any inconsistencies/trade-offs/conflicts among them, and refine and reaffirm the overall vision and definition of restoration success. This effort includes the development of total system performance measures and interim goals and targets for restoration.

RECOVER continues to assist CERP projects and other projects sponsored by the South Florida Water Management District (SFWMD or District) and U.S. Army Corps of Engineers (USACE), including Acceler8 projects and the System-wide Planning and Operations Team (SPOT). RECOVER assists CERP and Acceler8 projects in applying adaptive management, reviewing and assisting in the development of project performance measures and monitoring plans, evaluating final arrays of alternatives for system-wide effects, and providing additional resources as requested by project teams. One of these resources discussed in last year's SFER chapter is a benefit quantification methodology. During the past year, concerns have been expressed at senior levels that the current approach to benefits quantification is seriously flawed and, thus, RECOVER is currently developing suggestions for alternative methodologies. The RECOVER team provides support to the SPOT team in its effort to improve the modeled performance of an updated CERP, referred to as CERP A, through operational optimization and project modifications, and to participate in the development of a revised system operating manual.

SYSTEM STATUS REPORT SUMMARY

The *2007 System Status Report* (RECOVER, 2007) provides an in-depth analysis of monitoring data from the CERP MAP (RECOVER, 2004) in conjunction with historical data and data from other sources with the goal of providing an assessment of the ecological condition and status of the South Florida ecosystem. This information provides a baseline against which to measure CERP effects. This report will be consulted and referenced by the USACE and SFWMD when preparing assessment reports as required by the Programmatic Regulations (DOD, 2003).

System status reports are unique in that they examine trends in physical, chemical, and biological/ecological variables that CERP is expected to affect in the context of conceptual ecological models and groups of working hypotheses that are described in the *2006 Assessment Strategy for the Monitoring and Assessment Plan* (RECOVER, 2006a). Provided in the following sections are summaries of assessments for a small subset of the attribute/stressor indicators addressed in the *2007 System Status Report* (RECOVER, 2007). Complete assessments of these indicators, assessments of other indicators, and findings regarding relationships between stressors and attributes are provided in the *2007 System Status Report* (RECOVER, 2007).

The *2007 System Status Report* does not provide a complete CERP baseline. Many of the data sets are limited to a few years, so estimates of pre-CERP conditions for many hypotheses and associated performance measures remain uncertain. Also, it is important to recognize temporal response variability in order to fully appreciate limits to establishing pre-CERP conditions at this stage in Everglades restoration. A key goal of the assessment process is to determine if observed changes in variables are true deviations from natural variability and ultimately whether those changes might be caused or remedied by CERP.

It is important to note that the *2007 System Status Report* has a 2005–2006 reporting period, while most of the 2008 SFER has a 2006–2007 reporting period. System status reports are assembled from work done by a large number of contracted independent scientists and monitoring entities; it is a long and arduous process to integrate and synthesize data within and across the various geographic modules. Results, discussions and figures in the *2007 System Status Report* reflect the complexity of the assessment. RECOVER is in the process of developing a graphic summary to the *2007 System Status Report* that will include new ways of representing ecological data in easy-to-understand formats.

LAKE OKEECHOBEE MODULE

The ecological recovery of Lake Okeechobee (**Figure 7B-1**) is critical to the success of the Everglades restoration plan. The lake is a primary source of water for restoration of the natural hydrologic regime in the southern half of the system. Failure to realize effective measures to restore the lake will adversely affect or delay efforts to restore the downstream Everglades wetland systems and coastal estuaries that either rely on or are affected by water deliveries from the lake. Major stressors currently impacting Lake Okeechobee include high and low lake stages, high nutrient loading from anthropogenic activities in the watershed, frequent high water column turbidity due to periodic resuspension of nutrient-laden flocculent sediments, and the presence of exotic and invasive plant and animal species (RECOVER, 2006a). This section focuses on stage, SAV and littoral zone vegetation hypothesis clusters. The *2007 System Status Report* (RECOVER, 2007) details the progress and results in the context of all hypothesis clusters as described in the final draft of the *2006 Assessment Strategy for the Monitoring and Assessment Plan* (RECOVER, 2006a).

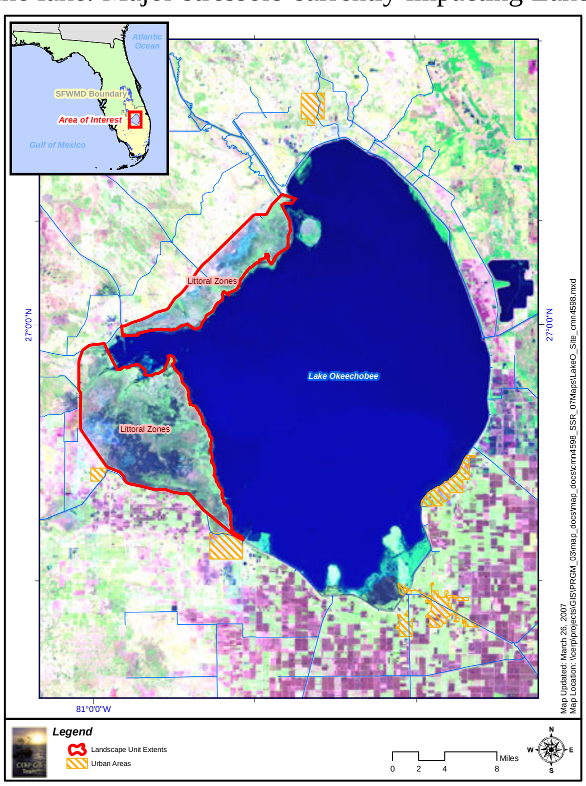

Figure 7B-1. Lake Okeechobee module boundary.

Lake Stage

While a certain degree of natural variation in lake stage benefits the plant and animal communities in Lake Okeechobee, extreme high and low lake levels, and moderately high and low lake levels of long duration, are major stressors affecting aquatic vegetation and the animal communities that utilize these plants for habitat and sustenance. In general, lake stage should never exceed 17 feet and rarely go below 11 feet. One extreme low-stage event at a frequency of once per decade is currently believed to be beneficial to oxidize muck sediment and facilitate germination of the bulrush seed bank. In addition, the lake's stage should be neither greater than 15 feet nor less than 12 feet for more than 12 consecutive months. Gradual recession of water from a winter high near 15.5 feet to a spring low of near 12.5 feet should occur most years (30 out of 36).

Since implementation of the current Lake Okeechobee Water Supply and Environmental Operating Schedule, the lake has experienced an increased frequency of high lake stages (**Figure 7B-2**). Efforts are under way to adjust the lake stage regulation schedule to keep the lake at lower stages and optimize the lake's operating schedule within existing structural constraints to meet diverse requirements of the lake, its receiving waters and its users until programs, such as CERP, are implemented (**Figure 7B-3**).

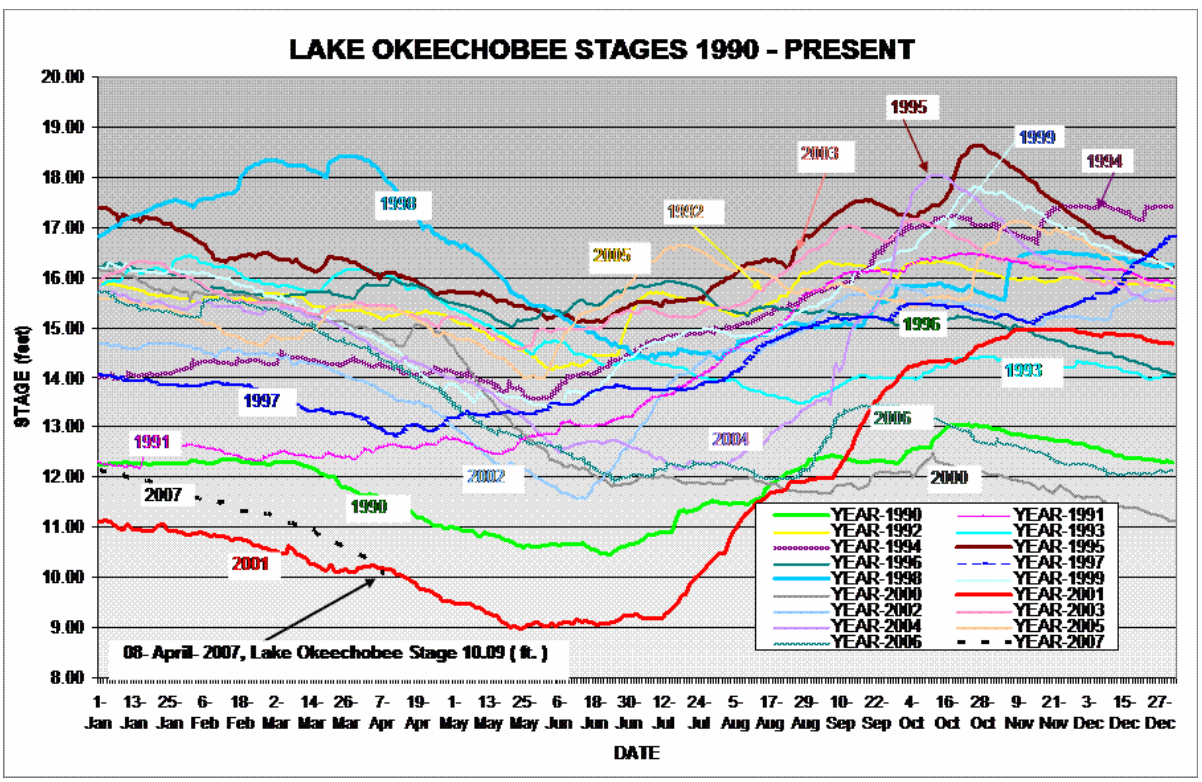

Figure 7B-2. Lake Okeechobee stages between 1990 and spring 2007.

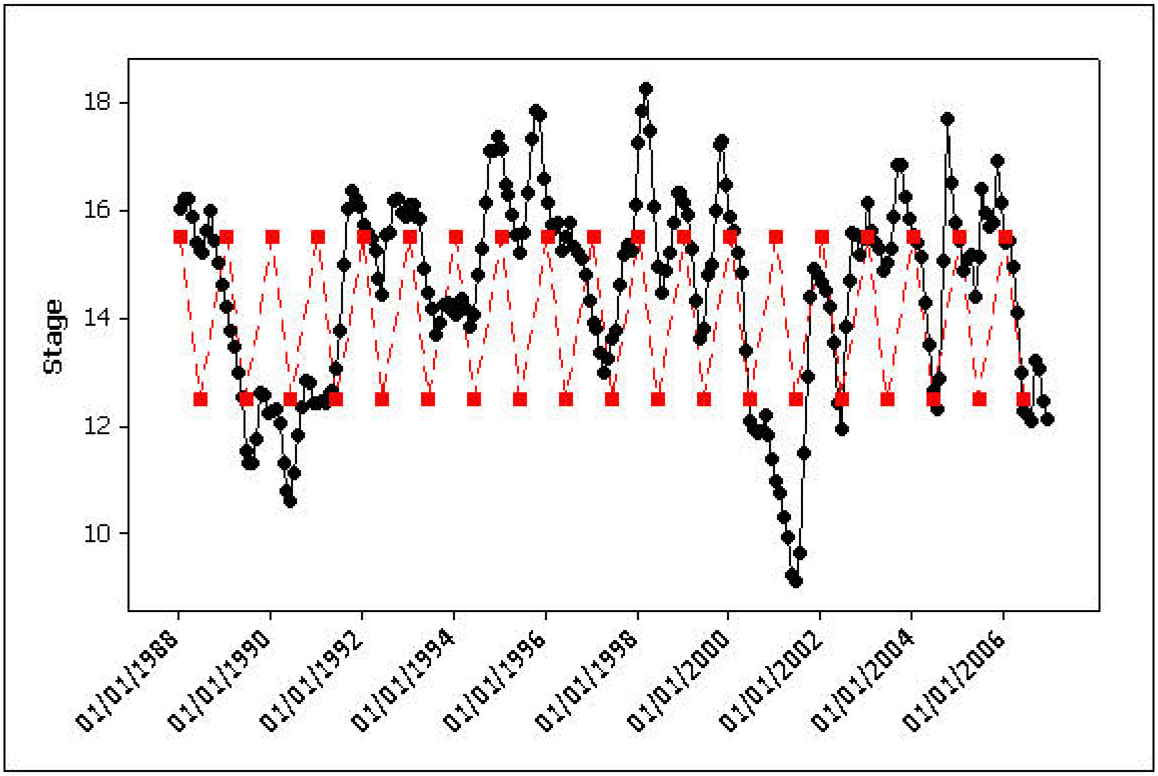

Figure 7B-3. Mean monthly stage data in feet above mean sea level, 1988 through 2006, showing the fluctuating year-to-year stage as a function of desired stage (in black) and desired recession rates from January high of 15.5 to June low of 12.5 (in red).

Submerged Aquatic Vegetation

Monitoring in Lake Okeechobee is conducted to assess changes in SAV in response to changes in water level, nutrient concentrations, and light availability. As CERP projects and other complimentary efforts improve conditions within the lake, detectable trends of expansion in SAV areal coverage and increased biomass are expected. Under existing watershed uses and lake management activities, the spatial extent and abundance of SAV varies widely from year to year. Along with macroinvertebrates, SAV may prove to be more responsive to environmental restoration than other indicators and should be the central focus of long-term monitoring efforts.

A large decrease in SAV was likely a response to poor light conditions, wind and wave-induced uprooting, and high water levels caused by three hurricanes, two in 2004, and one in 2005. SAV areal coverage was 54,875 ac in late summer 2004. Coverage was reduced to 10,872 ac in late summer 2005 and further reduced to 2,965 ac in late summer 2006 (**Figures 7B-4a through 4c**). Average SAV biomass declined from 32.3 to 4.7 g dry wt m^{-2} following the hurricanes (**Figure 7B-5**). However, from January 2005 to June 2006, SAV biomass continued to decline from 4.46 g dry wt m^{-2} to less than 0.04 g dry wt m^{-2}. Although declines over the winter period are expected due to seasonal conditions such as lower temperatures, increased turbidity and shorter photoperiod, the significant declines observed are primarily a result of long-term light deprivation related to water quality and lake stage effects.

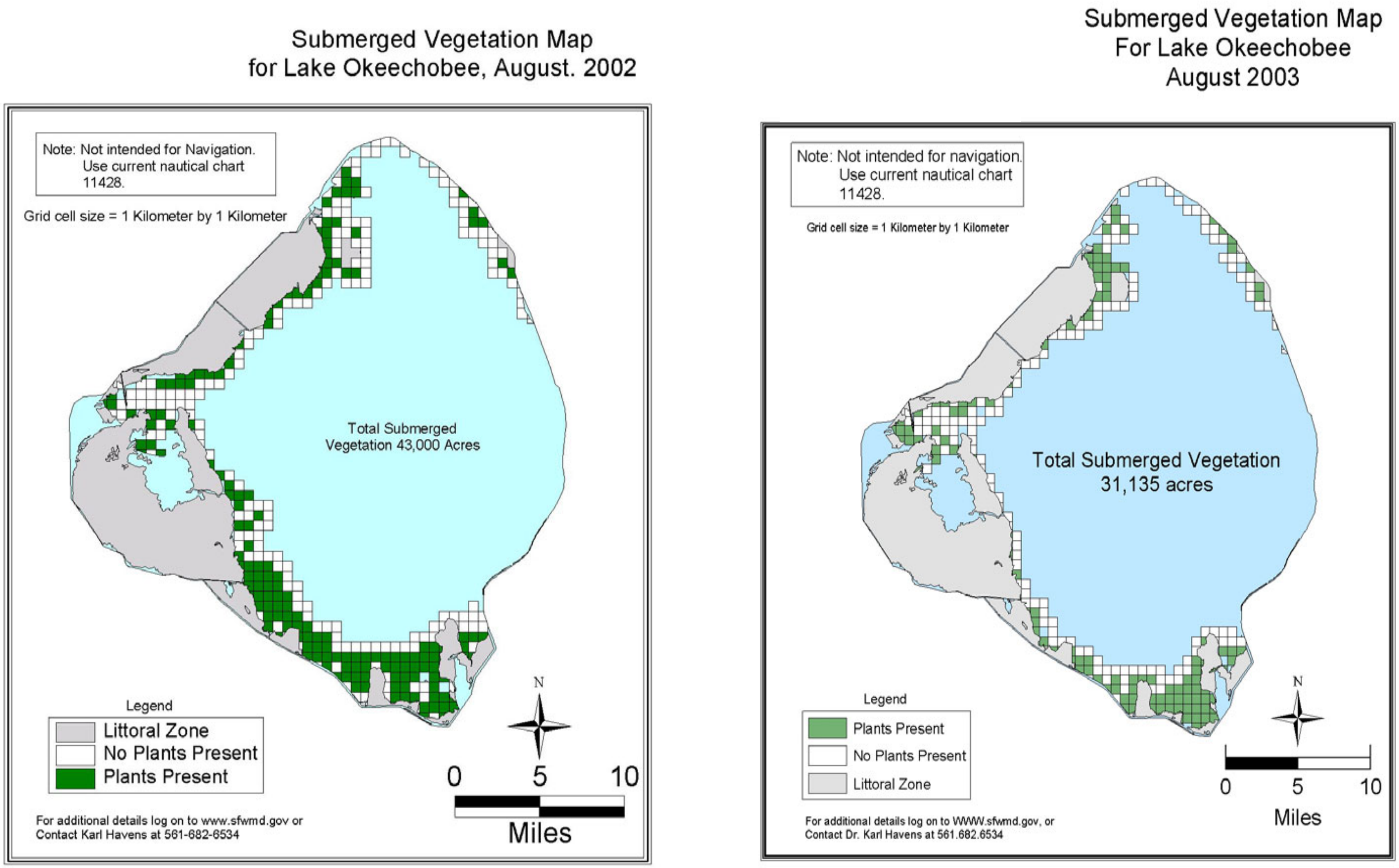

Figure 7B-4a. SAV biomass from August 2002 through August 2003.

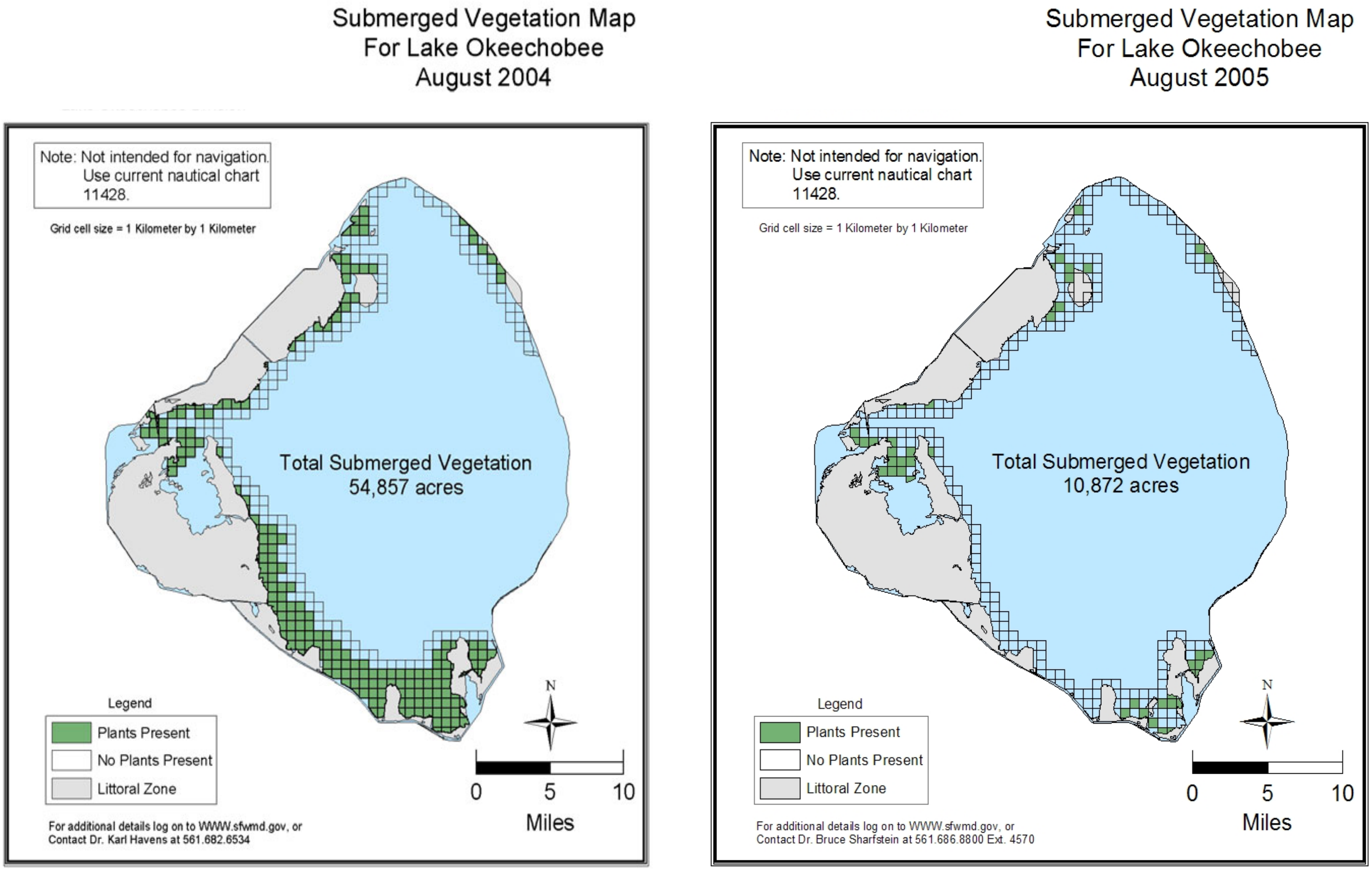

Figure 7B-4b. SAV biomass from August 2004 through August 2005.

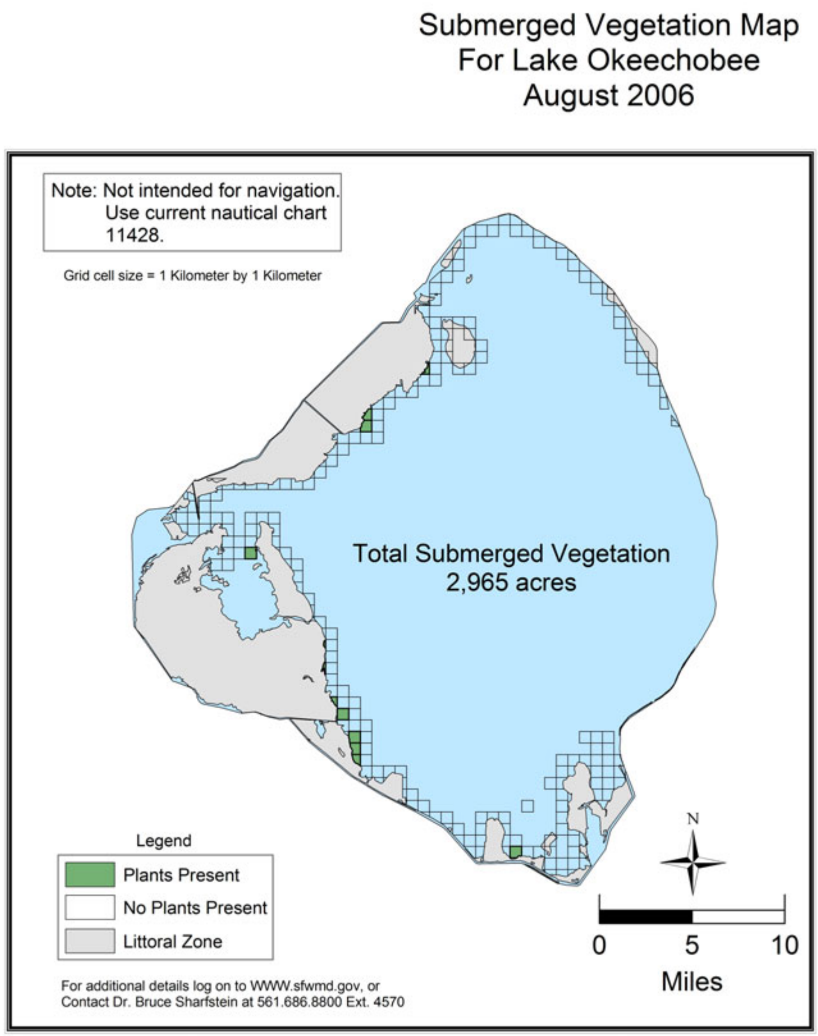

Figure 7B-4c. SAV biomass at August 2006.

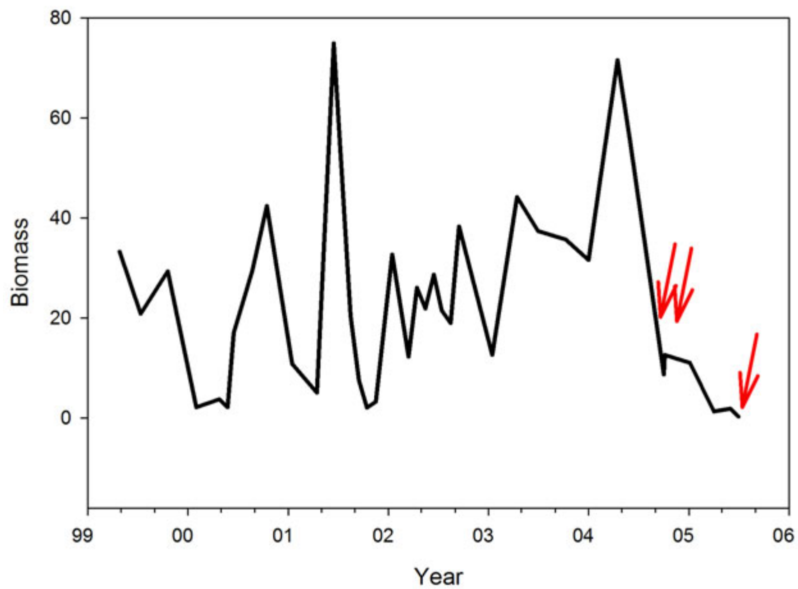

Figure 7B-5. SAV biomass over time. Red arrows denote hurricanes impacting the lake.

The acreages of dominant plants in 2006, as compared to 2005, are presented in **Table 7B-1**. *Chara* spp. is a macro-alga, rather than a true vascular plant, and is a considered pioneer vegetation for freshwater lakes, hence its relatively extensive coverage in 2006.

Table 7B-1. Acreage of dominant SAV plants in 2005 and 2006.

Genus	2005 Acreages	2006 Acreages
Vallisneria	494	750
Hydrilla	7,166	0
Potamogeton	494	0
Ceratophyllum	7,166	495
Chara	247	2,470

Littoral Zone Vegetation

Lake Okeechobee's littoral zone covers an area larger than 400 square kilometers (km^2). Emergent vegetation within this zone provides nesting habitat for fish, birds, and alligators; stabilizes sediments; provides substrate for macroinvertebrates; supports attached algae (epiphytes) that help to remove phosphorus from the water; and protects SAV beds from waves. Distribution and abundance of emergent plants are strongly influenced by hydroperiod, nutrient inputs and exotic vegetation.

Giant bulrush (*Scirpus californicus*) stands, located in Lake Okeechobee at lake-bed elevations of 10 to 10.5 feet National Geodetic Vertical Datum (ft NGVD) appeared to suffer damage when exposed to prolonged periods of deep flooding. An evaluation of influence of water depth on persistence of giant bulrush was conducted to support prudent lake management and minimize adverse effects of stage level manipulation. Results of this study indicate that undisturbed bulrush can persist at a water depth of 3 feet or less (lake stage of 13–13.5 ft NGVD); however, prolonged periods of water depths greater than 3 feet may cause a reduction in aerial coverage of bulrush stands. Disturbances such as herbivory (plants eaten by animals) or strong winds appear to reduce ability of giant bulrush to persist at 3-feet inundation. Based on data collected from this study, inundation of bulrush stands should be maintained at less than 3 feet to minimize the adverse effects of stage level manipulation on the persistence of giant bulrush.

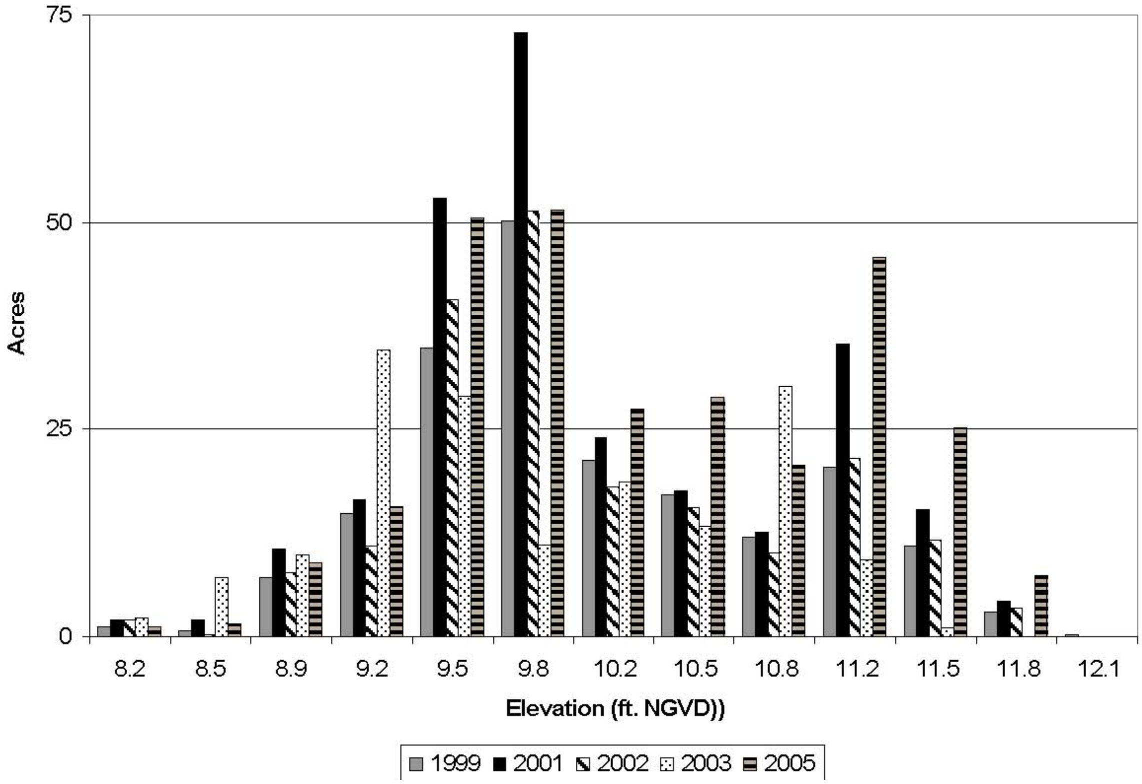

Figure 7B-6. Aerial coverage and distribution of bulrush by calendar year (1995–2005) and elevation along the lakeward edge of the northwest marsh.

Distribution of bulrush along the northwest marsh edge has been monitored closely since 1999 (**Figure 7B-6**). Bulrush coverage varied from 194 ac in 1999, 266 ac in 2001, 193 ac in 2002, 167 ac in 2003, to 285 acres in 2005. The increase in bulrush coverage in 2001 occurred in conjunction with a large reduction in lake stage during a drought. Reductions in bulrush coverage after 2001 occurred in conjunction with prolonged exposure to extreme dry conditions (sediments exposed > 4 months) followed by exposure to excessive flooding depths that exceeded 2 meters. Distribution and areal coverage of vegetation in Lake Okeechobee's marsh during 2003 is presented in **Figure 7B-7**. Cattail covered 23,840 acres. At elevations in the marsh generally greater than 13.5 ft NGVD, torpedograss coverage was greater than 17,000 acres. Distribution of fragrant water lily was nearly 11,000 acres. Although fragrant water lily is a native, excessive growth of this plant may not be desirable because large amounts of detrital material can accumulate in dense lily beds.

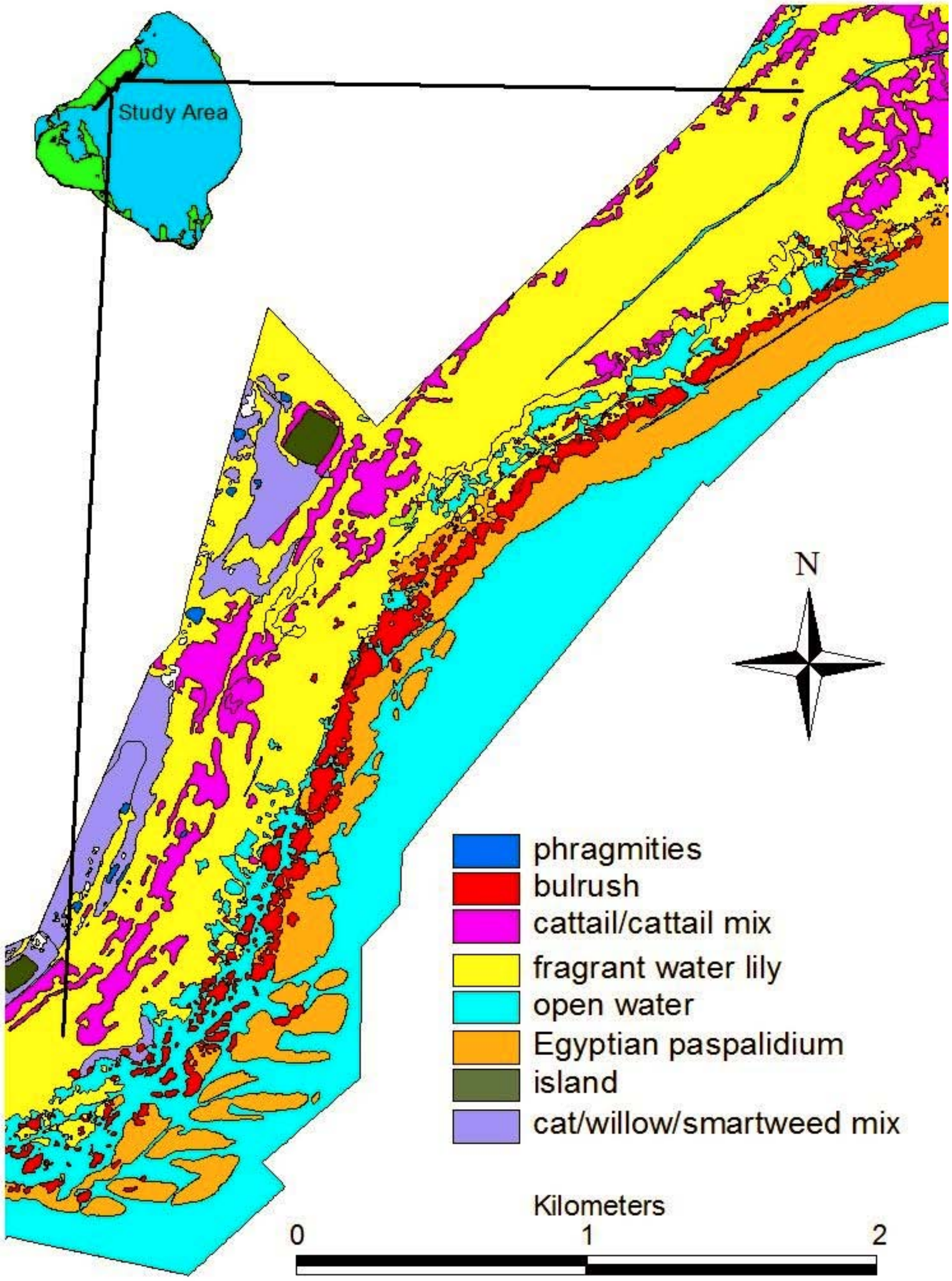

Figure 7B-7. Dominant emergent vegetation pattern in Lake Okeechobee in 2003.

NORTHERN ESTUARIES MODULE

The Northern Estuaries Module includes the Caloosahatchee River and Estuary, San Carlos Bay, and Estero Bay on the west coast and the St. Lucie Estuary, Southern Indian River Lagoon, Loxahatchee River Estuary and Lake Worth Lagoon on the east coast (**Figure 7B-8**). Detailed descriptions of these individual water bodies can be found in the *2006 System Status Report* (RECOVER, 2006b). Historically, natural freshwater discharges into these water bodies sustained an ecologically appropriate range of salinity conditions necessary for native floral and faunal communities. Urbanization of Florida's coastal regions and the ensuing increased demand for water and flood control has led to frequent high and low salinity extremes within these coastal water bodies. Implementation of CERP will help mitigate frequency and duration of water releases and consequent rapid salinity shifts. Water storage and water quality features will be constructed and natural wetlands restored. Removal of anthropogenically produced mucky sediments in the water bodies will also be needed to achieve water quality and clarity goals. This section focuses on the SAV and oyster hypothesis clusters. The *2007 System Status Report* details progress and results in context of all hypothesis clusters as described in the *2006 Assessment Strategy for the Monitoring and Assessment Plan* (RECOVER, 2006a).

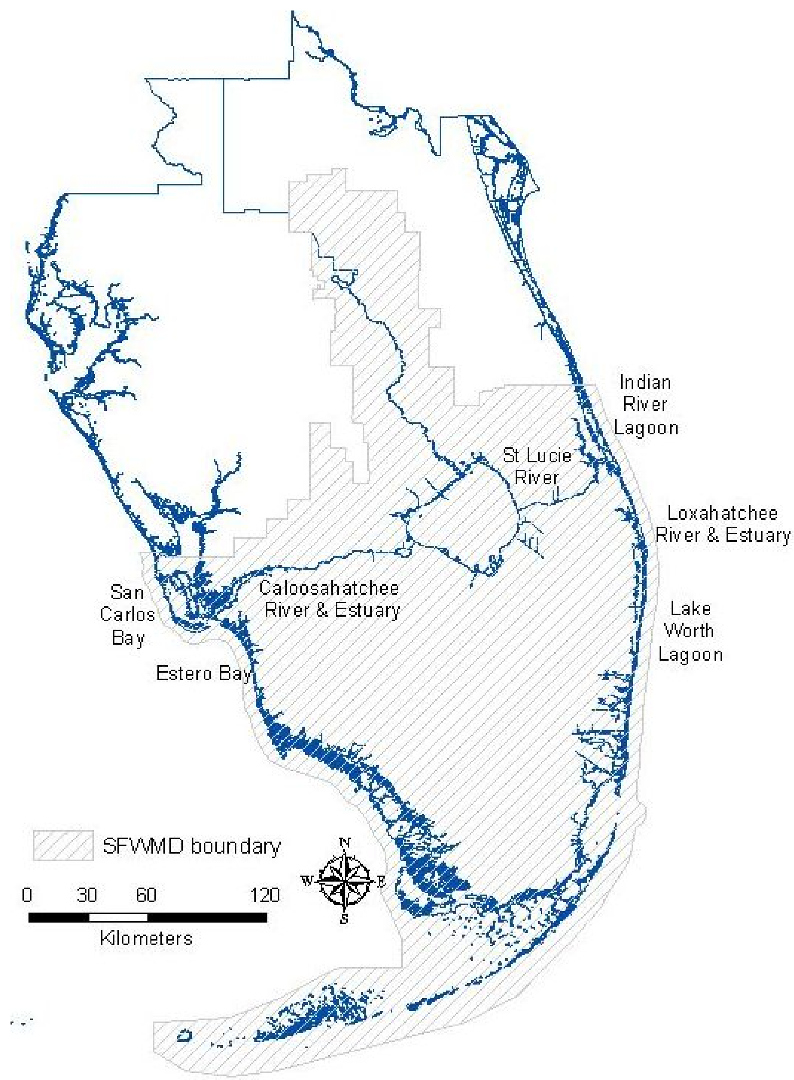

Figure 7B-8. Northern Estuaries Module boundaries.

Submerged Aquatic Vegetation

Monitoring of SAV in the Northern Estuaries is conducted to assess working hypotheses that spatial extent, distribution and function of SAV will be increased by restoring more natural salinity regimes, removing mucky sediments, and decreasing levels of nutrients, dissolved organic matter, and turbidity. SAV maps were developed for portions of the Northern Estuaries. The 2006 SAV map for Charlotte Harbor, which receives freshwater inflows from the Caloosahatchee River, is presented in **Figure 7B-9**. **Figure 7B-10** is a map of SAV in 2006 within Southern Indian River Lagoon and lower St. Lucie Estuary (downstream of the Roosevelt Bridge).

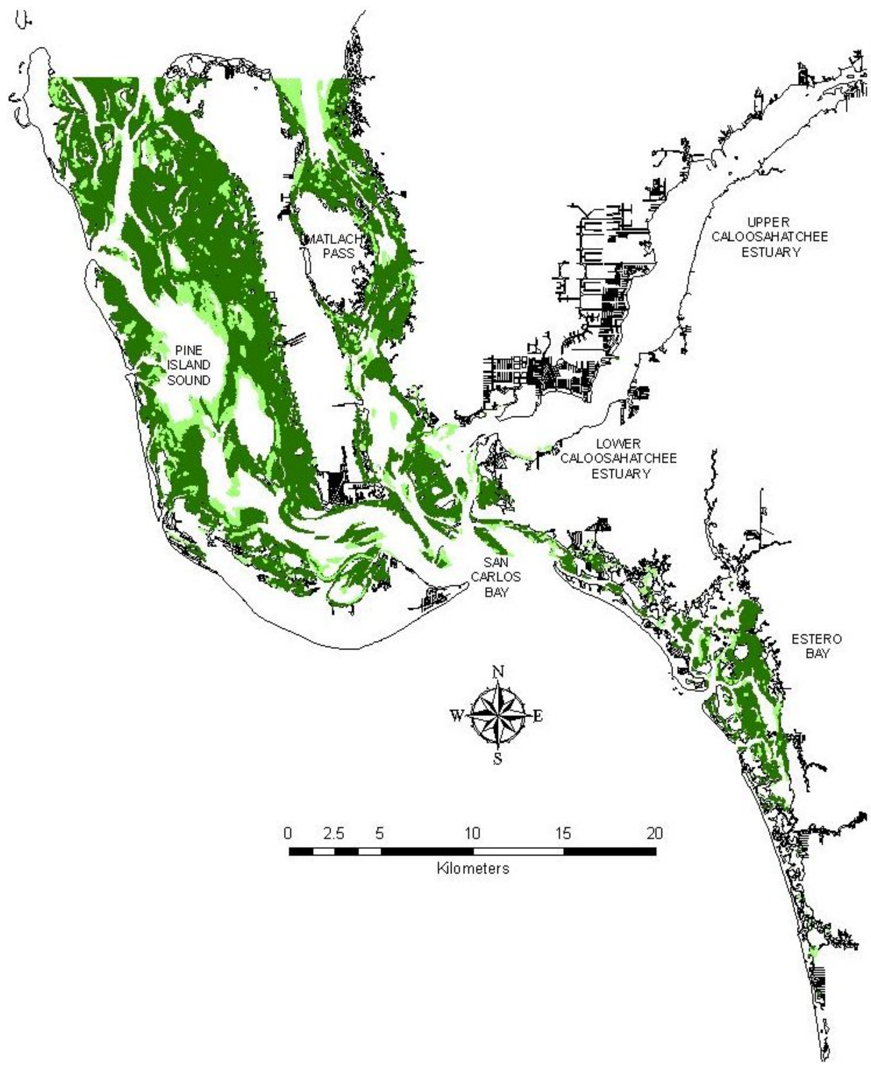

Figure 7B-9. Submerged aquatic vegetation areal extent and distribution in Charlotte Harbor in 2006.

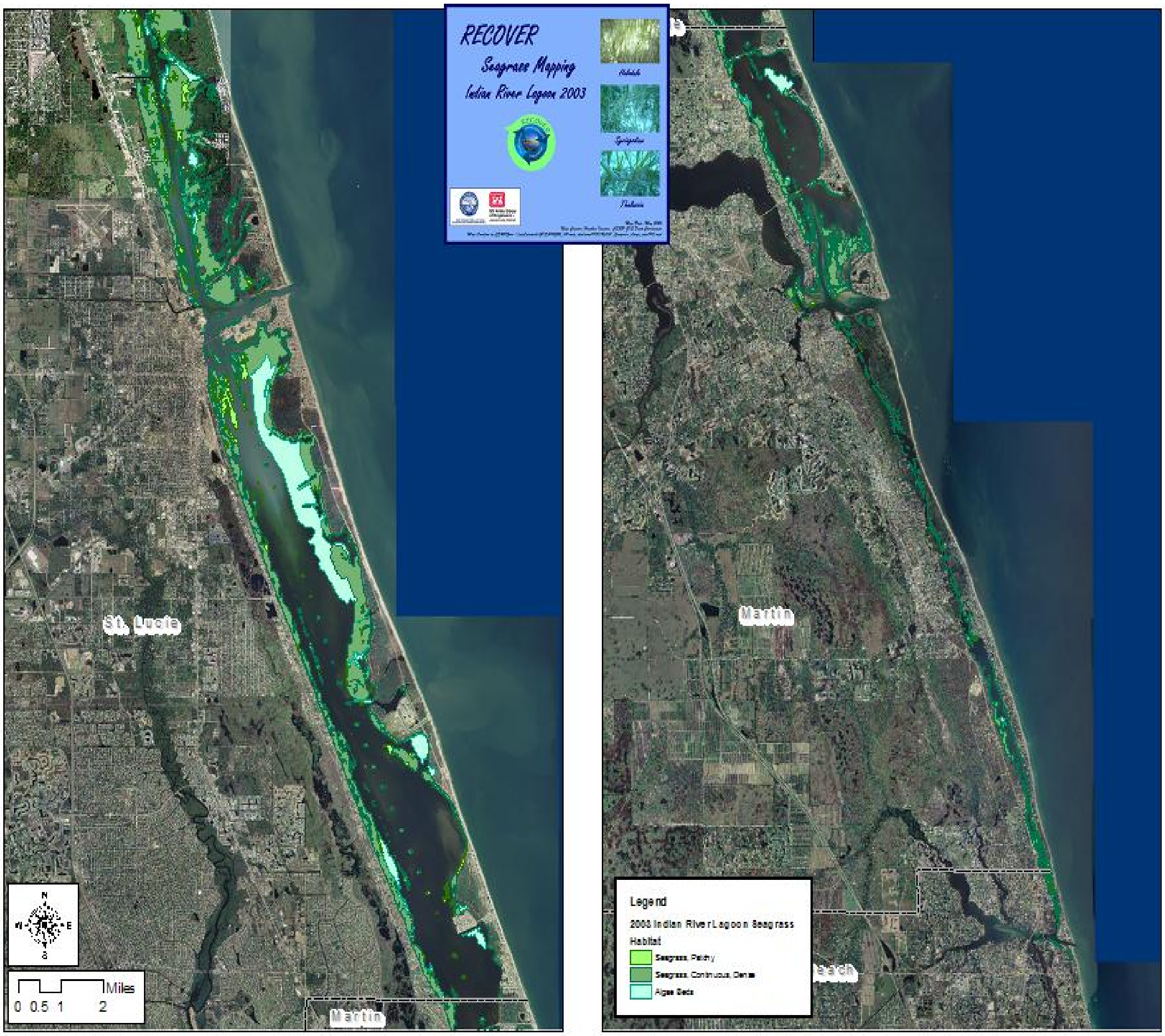

Figure 7B-10. SAV areal extent and distribution in southern Indian River Lagoon.

Less than 50 percent of potential seagrass habitat (< 1.7 m deep) in the Southern Indian River Lagoon and St. Lucie Estuary is covered by seagrass. This estuary has 19,799 ac of potential seagrass habitat. From 1986 to 1999, seagrass coverage ranged from 7,808 ac in 1999 to 9,864 ac in 1996. An initial review of seagrass mapping data from 1999–2006 shows that seagrass acreage in the section of the lagoon between Stuart Causeway and St. Lucie Inlet, which is influenced by St. Lucie River discharges, remained fairly stable from 1999 through 2003. Acreage of dense, continuous seagrass declined dramatically following the 2004 and 2005 hurricanes and associated Lake Okeechobee discharges. While the maps created from aerial photographs are not species-specific, field inspections indicate that many of the "no change" areas are dominated by shoal grass (*Halodule wrightii).* At least some of the areas of significant loss are known to have been dominated by manatee grass (*Syringodium filiforme*). Shoal grass is more tolerant of low salinities and salinity variation than manatee grass, which helps explain its persistence.

In 2001, aerial photographs were interpreted to determine seagrass coverage in Lake Worth Lagoon. The north segment was determined to have the majority of seagrass, 1,134 ac, followed by the south segment with 300 ac, and the central segment with 192 ac of seagrass. The total coverage was determined to be 1,626 ac of seagrass. The north segment is not anticipated to be impacted by CERP implementation. The central segment, which should see most improvement due to CERP implementation, has 729 ac of suitable habitat (< 5.0 ft NGVD), of which only 192 ac was found to be colonized by SAV in 2001. The south segment has 536 ac of suitable habitat (< 4.0 ft NGVD), of which only 300 ac were colonized by SAV in 2001.

Dramatic decreases (~24 percent) were seen in seagrass percent cover within the Loxahatchee River Estuary following the 2004 hurricane season. Throughout the next 12 months of post-hurricane monitoring of *S. filiforme*, no appreciable recovery occurred; however, *Halophila johnsonii* increased from < 10 percent (immediately following the hurricanes) to > 60 percent (12 months post-hurricanes).

Salinity is an important and controlling environmental variable for SAV that CERP has to consider especially when setting desired flow levels in the Northern Estuaries. Of additional importance are interactions between salinity and light attenuation and tolerances to rapid salinity changes to the health and distribution of SAV. A better understanding is needed of species-specific growth responses to the dynamics of freshwater discharge rates and timing, especially on different stages of plant development.

Oyster Reef Coverage

Monitoring of Eastern oysters (*Crassostrea virginica*) in the Northern Estuaries is conducted to assess the working hypothesis that undesirable shifts in salinity, accumulation of muck, and increased sediment loads have decreased survival, reproduction, spat recruitment and growth of oysters, and increased their susceptibility to predation and diseases (RECOVER, 2006a). Restoration of more natural freshwater inflows and muck removal, as a result of CERP implementation, should provide beneficial salinity and habitat conditions that promote the reestablishment of healthy oyster beds.

Surveys were performed in 2004 and 2005 to determine current oyster reef locations and acreages within the Northern Estuaries. Caloosahatchee Estuary has 18 acres of live oyster bars (**Figure 7B-11**), St. Lucie Estuary has 117 acres (**Figure 7B-12**), Loxahatchee River Estuary has 10 acres (**Figure 7B-13**), and Lake Worth Lagoon has approximately 18 acres (**Figure 7B-14**).

Oyster reefs occupying the various estuaries in southeast Florida are not isolated entities but are instead linked to one another via exchange of larvae. An understanding of larval exchange is a necessary precursor to the proper management of oyster reefs in Florida. A plan to map the extent of oyster reef development (spatial coverage in acres) needs to be developed and implemented in order to support the evaluation of oyster areal extent as an interim goal (RECOVER, 2005).

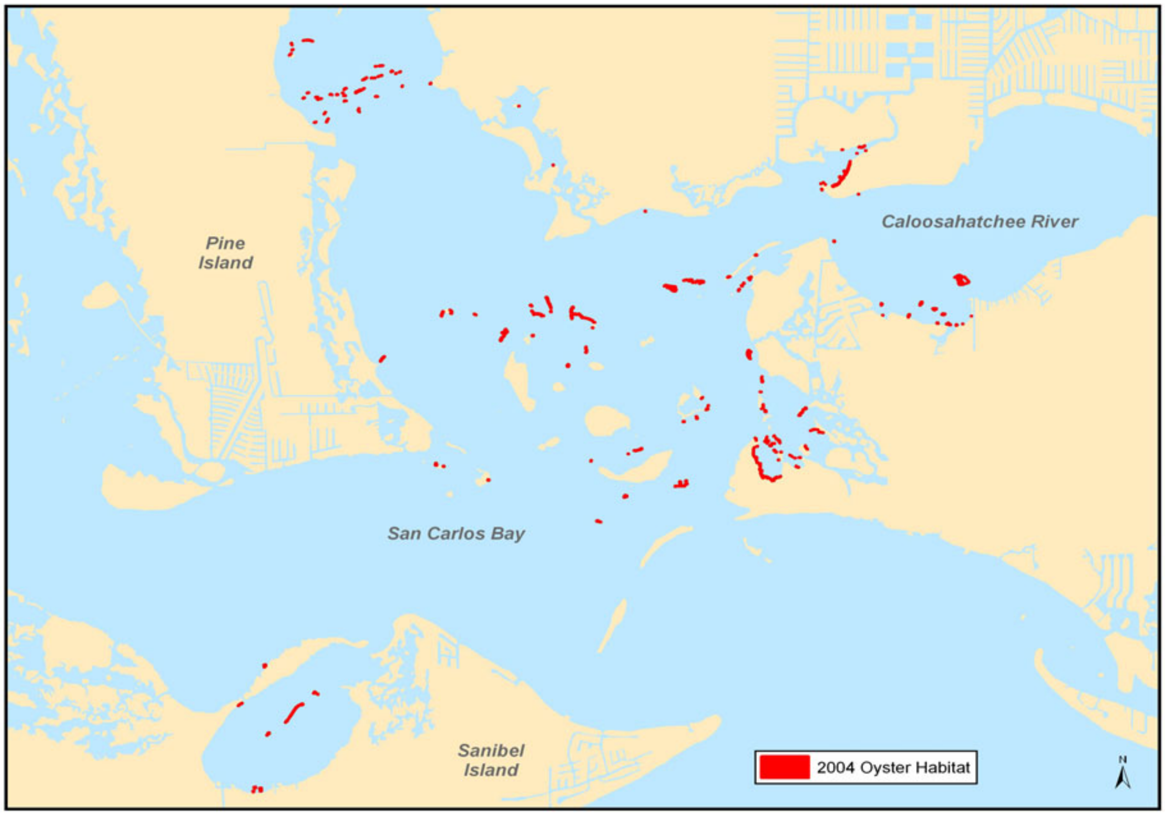

Figure 7B-11. Existing oyster habitat in the Caloosahatchee River and Estuary.

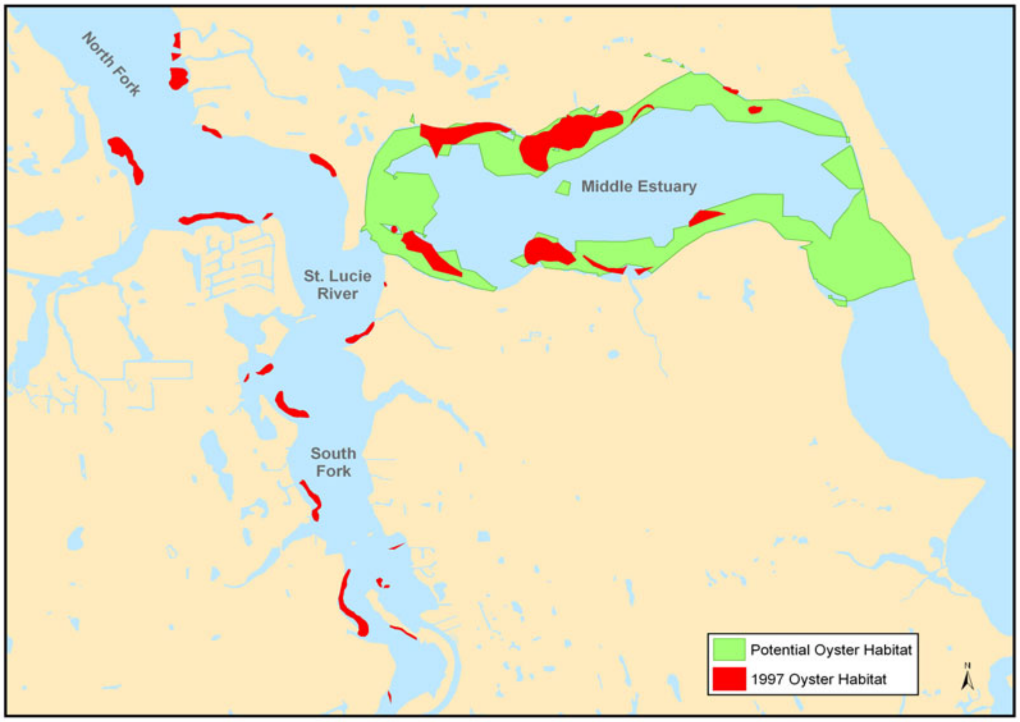

Figure 7B-12. Current and potential oyster habitat in the St. Lucie Estuary.

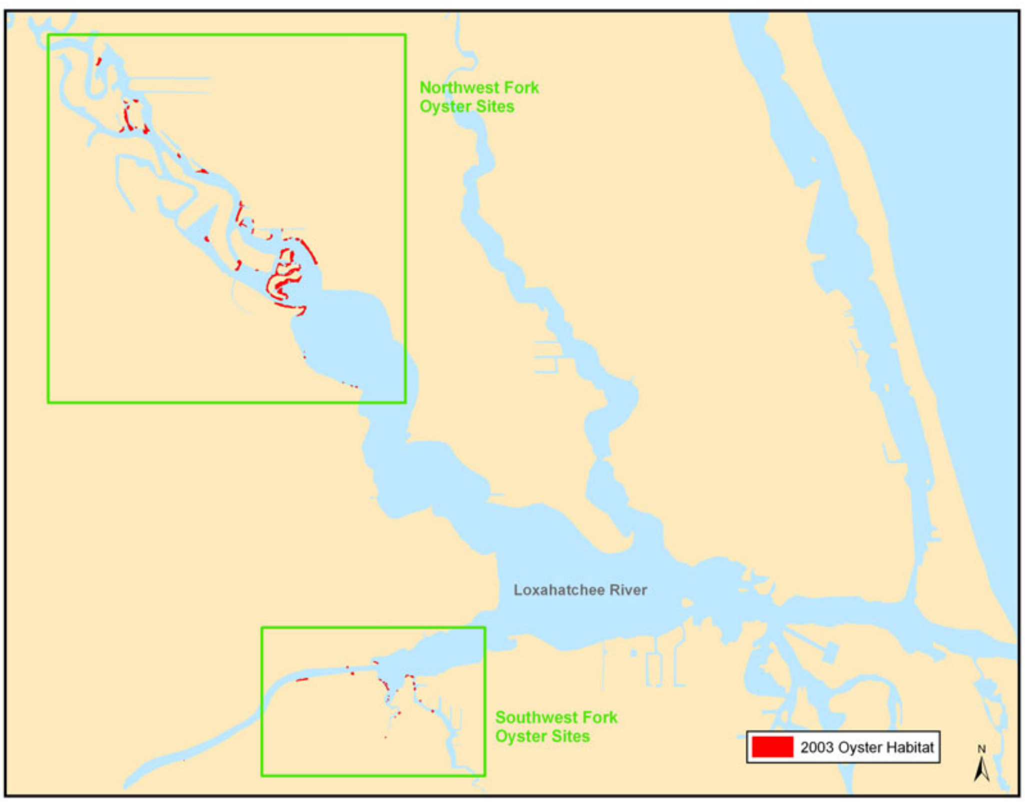

Figure 7B-13. Existing oyster habitat in the Loxahatchee River and Estuary.

Figure 7B-14. Existing oyster habitat in Lake Worth Lagoon.

GREATER EVERGLADES WETLANDS MODULE

The Greater Everglades Wetlands Module boundary encompasses the remaining portion of the Everglades wetlands, which includes a mosaic of interconnected freshwater wetlands and estuaries located primarily south of the Everglades Agricultural Area, in addition to the Lake Okeechobee littoral zones and the hydric pinelands and seasonal wetlands of the J.W. Corbett/Pal Mar/Dupuis Wildlife Management Area (**Figure 7B-15**). Major stressors currently impacting greater Everglades wetlands include disruption of sheet flow and associated hydropatterns, sea level rise, nutrient inputs and eutrophication, and invasive non-native plants and animals.

The volume, timing, and distribution of sheet flow, in combination with direct rainfall, produced fundamental hydrologic and landscape characteristics of the pre-drainage Everglades. Therefore, ecological restoration goals and strategies for greater Everglades wetlands encompassed effects of hydrology on (1) interior gradients of water quality and resulting distribution of soil nutrients; (2) coastal gradient of flow, salinity, and nutrients; (3) wetland landscape pattern and extent; and (4) trophic levels of food chains supporting higher vertebrates (RECOVER, 2004). Decompartmentalization combined with resumption of natural volume, distribution, and timing of freshwater delivery is expected to restore sheet flow and pre-drainage hydrologic and landscape characteristics to an undivided ecosystem encompassing much of Water Conservation Areas (WCAs) 3A and 3B, eastern Big Cypress, and the ENP (RECOVER, 2006a).

This section focuses on the predator-prey interactions of wading birds and aquatic fauna forage base hypothesis cluster. The *2007 System Status Report* details progress and results in the context of all hypothesis clusters as described in the *2006 Assessment Strategy for the Monitoring and Assessment Plan* (RECOVER, 2006a). This summary is for data collected from the 2006 wet season through the beginning of the 2006/2007 dry season.

Integration of primary datasets for the *2007 System Status Report* was achieved via a visual overlay of the various spatial data layers and, for that reason, these assessments represent the first step in the larger more complex statistical integration of data. It must be recognized that processes to complete statistical analysis of this integration are currently undefined and will require an iterative and interactive process between various scientists and agencies.

Predator-Prey Interactions of Wading Birds and Aquatic Fauna Forage Base

Monitoring and assessment of wading bird-aquatic fauna predator-prey interactions is based on the hypothesis that restoration of natural hydrologic conditions will reestablish distributions of prey densities and concentrations across the landscape that in turn will support the return of large, successful wading bird nesting colonies to the southern Everglades (RECOVER, 2006a). The strategy for integrated assessment of wading bird/aquatic fauna predator-prey relationships is to annually track production of aquatic fauna populations during the wet season, concentration of those populations during the subsequent dry season, and distribution and size of wading bird nesting colonies in response to prey populations. Wading bird response to prey populations and water conditions during June 1, 2005–May 31, 2006, is assessed by comparing distribution and biomass of wet and dry season prey populations to distribution and size of wading bird nesting colonies in addition to hydrologic conditions prior to and during nesting season.

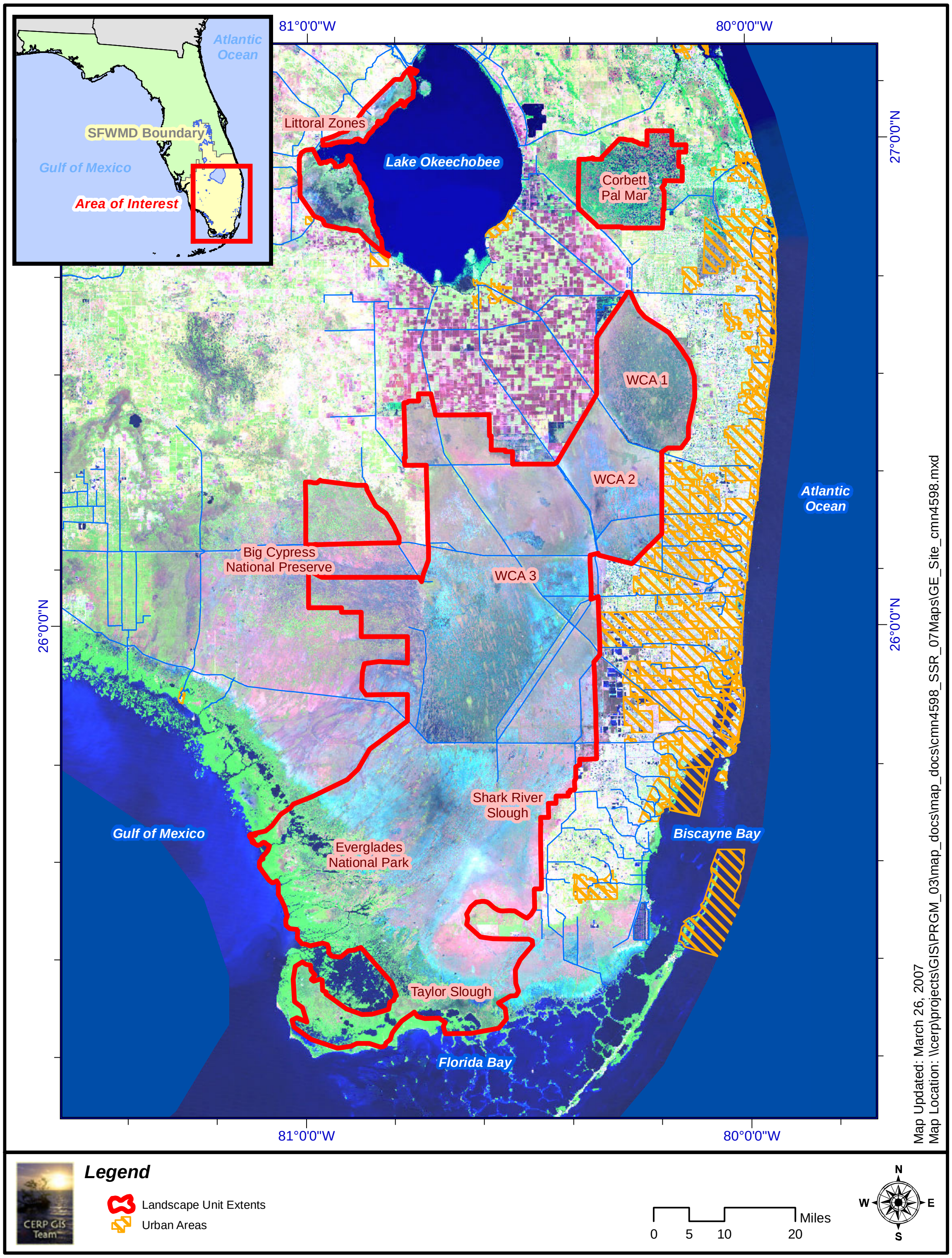

Figure 7B-15. Greater Everglades Wetlands Module boundary.

HYDROLOGIC CONDITIONS

Hydrologic conditions across the Everglades during the 2005 wet season and 2006 dry season supported a successful year for wading bird nesting throughout much of the system. Hydrologic conditions during the 2006 dry season were close to optimal for wading bird nesting. A steady and prolonged water level recession was unimpeded by major reversals. Late onset of the wet season in 2006 continued to provide ample foraging patches for fledging birds late in the nesting season.

PERIPHYTON NUTRIENT STATUS – 2005 LATE WET SEASON

Distribution of total phosphorus concentrations in periphyton mats during the 2005 late wet season (**Figure 7B-16**) indicates nutrient status of the Everglades at times and locations of throw-trap sampling for aquatic fauna prey biomass. The most notable new pattern to emerge from this map is elevated periphyton total phosphorus in the southern ENP above the marsh-mangrove ecotone of Gulf of Mexico drainages. This area represents a zone of peak productivity in most producers that appears to be caused by convergence of marine phosphorus and freshwater nitrogen sources as well as marine-derived phosphorus loadings from groundwater.

AQUATIC PREY POPULATIONS – 2005 LATE WET SEASON

During the 2005 late wet season, interpolation of marsh fish standing crop data indicated a uniform pattern across most of the Everglades and ranged from 0.2–0.4 grams per square meter (g/m^2) (**Figure 7B-17**). Regions of greater periphyton phosphorus concentration in the Lake Okeechobee littoral zone and in WCAs 1 and 3B appear to be associated with fish standing crops averaging 0.4–0.8 g/m^2. The exception was southern ENP above the marsh-mangrove ecotone of the Gulf of Mexico, which had low marsh fish biomass (< 0.2 g/m^2). The discrepancy of low marsh fish biomass in this area of otherwise high productivity was unexpected and may be important regarding the wading bird predator-prey hypothesis as this area encompasses the "fertile crescent" of freshwater and oligohaline marshes, which represented important feeding grounds within 9-km flight distances of historic wading bird nesting areas in the southwest Everglades. Future assessments will integrate regional hydrologic characteristics of the southern Everglades that might impact marsh fish populations despite overall higher productivity of the region.

Crayfish (*Procambarus alleni* and *Procambarus fallax*) biomass was high to the west of Shark River Slough where standing crops averaged 0.9–1.5 g/m^2 during the 2005 late wet season (**Figure 7B-17**). Crayfish standing crops were uniformly low (< 0.2 g/m^2) throughout most of the remaining Everglades. Regions of higher biomass occurred in ENP and WCA 1 marl prairies where crayfish standing crops averaged 0.3–0.6 g/m^2. Standing crops of marsh fish and crayfish did not increase as water levels declined during 2006 until surface water receded into isolated pools, and then levels were orders of magnitude higher than in areas that were previously flooded.

Grass shrimp represented less than 10 percent of aquatic fauna prey biomass throughout the greater Everglades wetlands during the 2005 late wet season (**Figure 7B-17**). Because of the small contribution of grass shrimp to prey biomass during the 2005 wet season, emphasis is placed on fish and crayfish in the following discussions of prey concentrations during the 2006 dry season.

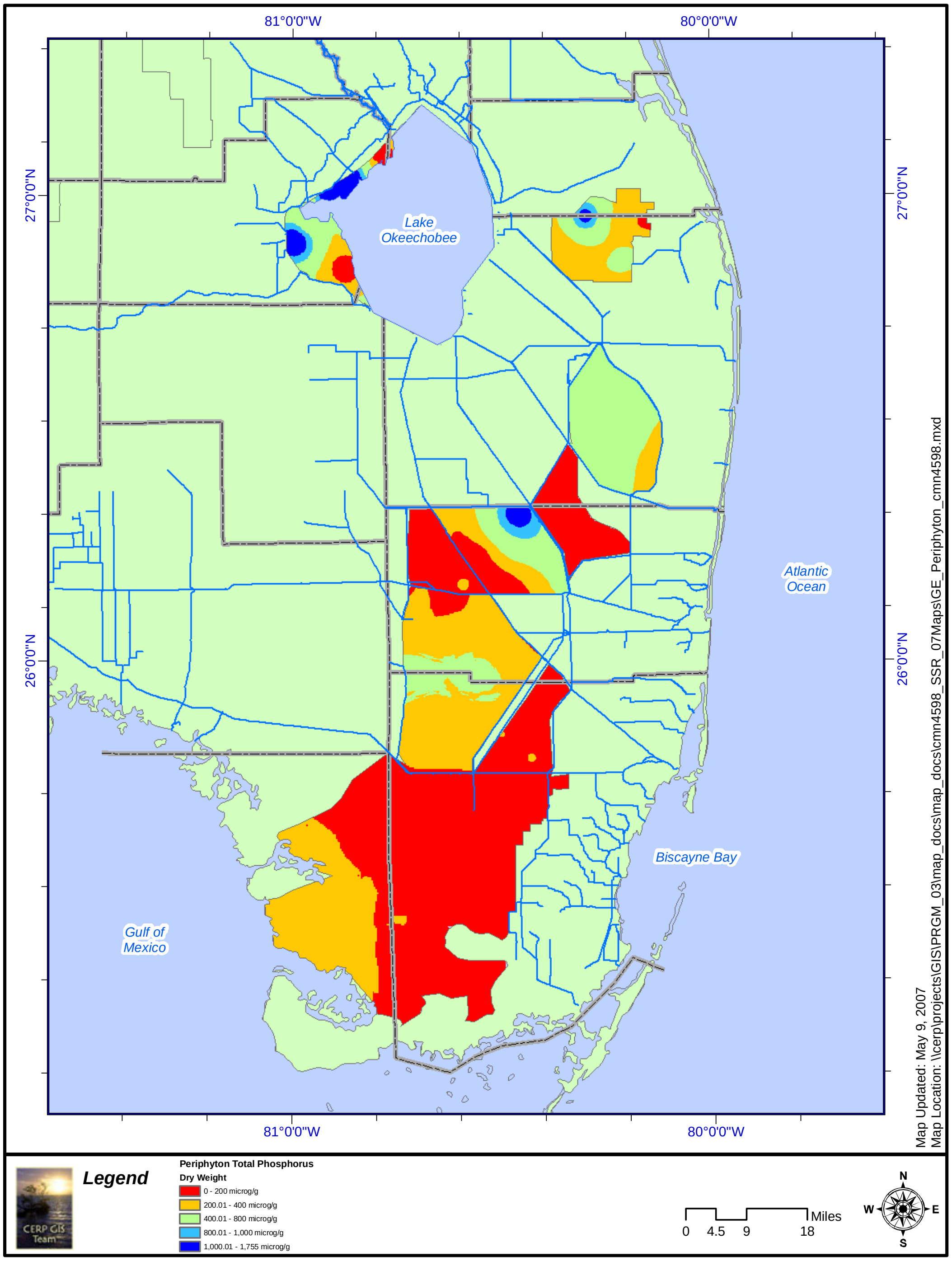

Figure 7B-16. Periphyton total phosphorus in the greater Everglades wetlands in 2005 late wet season.

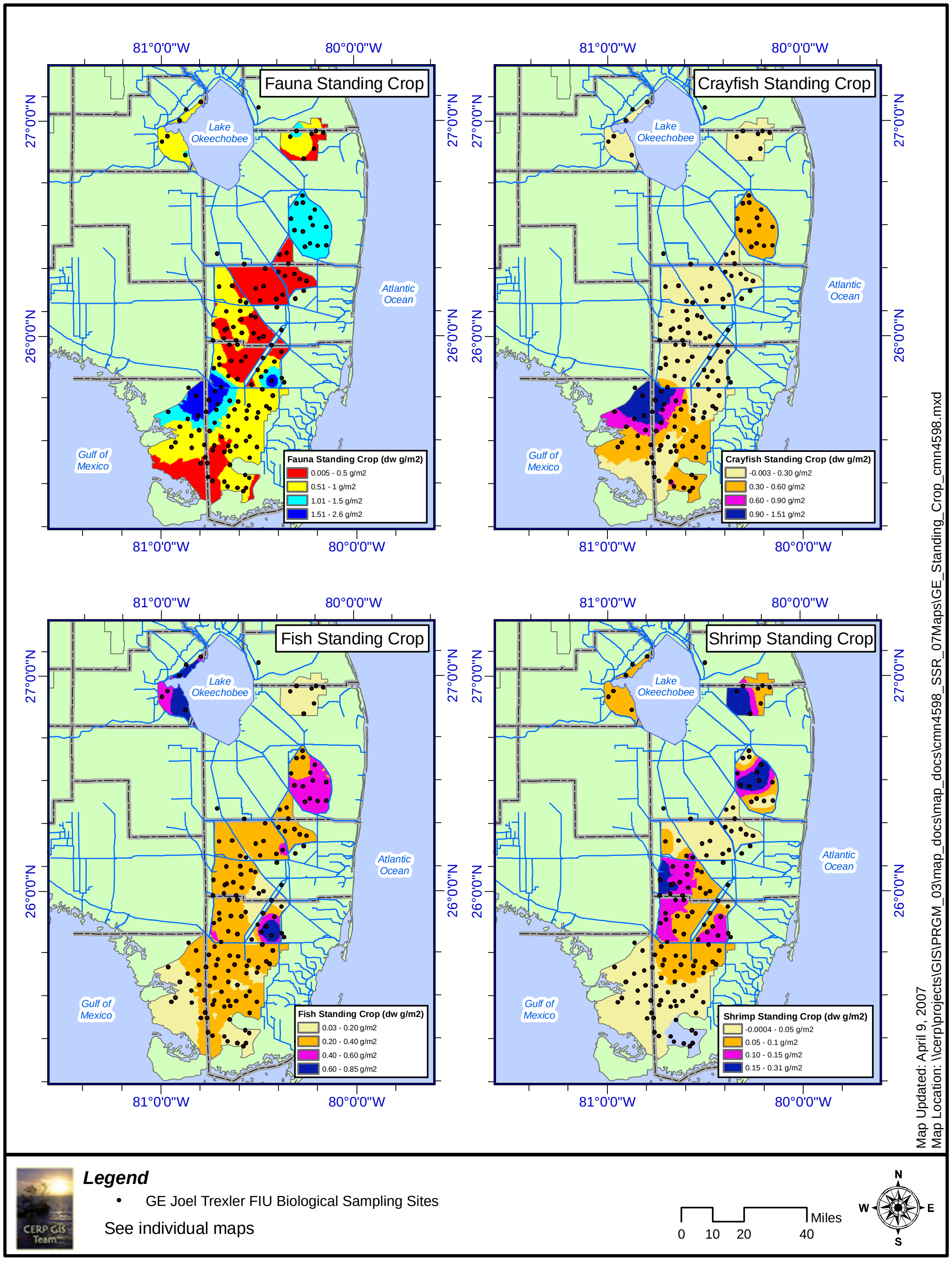

Figure 7B-17. Standing crop of aquatic fauna prey populations during the 2005 late wet season interpolated across the sampling domain of the Everglades. Circles indicate primary sampling units for throw trap sampling.

AQUATIC PREY POPULATIONS – 2006 EARLY AND LATE DRY SEASON

Standing crops of marsh fish and crayfish during the 2005 late wet season represented prey population that was potentially available for concentration and wading bird foraging as water levels receded during the 2006 dry season. However, standing crops did not increase as water levels declined during 2006 until surface water receded into isolated pools. Wet and dry seasons did not significantly differ in fish and crayfish standing crop in 10 landscape regions that were sampled during the 2005 late wet season and during February and April in the 2006 dry season (**Figure 7B-18**). Surface water persisted during February and April sampling periods in all regions with the exception of western Shark River Slough, where dry conditions in April 2006 prevented sampling.

AQUATIC PREY POPULATIONS – 2006 DRY SEASON

As surface water receded into isolated pools during the 2006 dry season, standing crops of fish and crayfish rose to levels that were orders of magnitude greater than in areas that were flooded during the previous wet season. Averages of standing crops of marsh fishes in isolated pools in WCA-2A and WCA-3A were about 20 times greater than those in the Park (**Figure 7B-19**). Mean fish standing crops of 0.2–0.4 g/m^2 during the 2005 wet season were concentrated to 135 and 70 g/m^2 during the 2006 dry season in isolated pools in southern WCA-2A and northwest WCA-3A. In the ENP, the wet season standing crops also averaged 0.2–0.4 g/m^2 during the prior wet season but were concentrated only to 2–13 g/m^2 during the 2006 dry season in isolated pools.

In contrast to marsh fish standing crops, mean crayfish standing crops in isolated pools were about 16 times greater in the Park compared to WCA-2A and WCA-3A during the 2006 dry season (**Figure 7B-19**). Mean crayfish standing crops of 0.3–1.5 g/m^2 during the 2005 wet season were concentrated to 8–36 g/m^2 during the 2006 dry season in the Park. In the WCAs, wet season standing crops, which averaged <0.3 g/m^2 during 2005, did not change in southern WCA-2A and increased to only 1.8 g/m^2 in northwest WCA-3A during the 2006 dry season. Higher dry season standing crops of crayfish in concentration patches in the Park, in comparison to the WCAs, corresponded to higher standing crops of crayfish during the previous wet season.

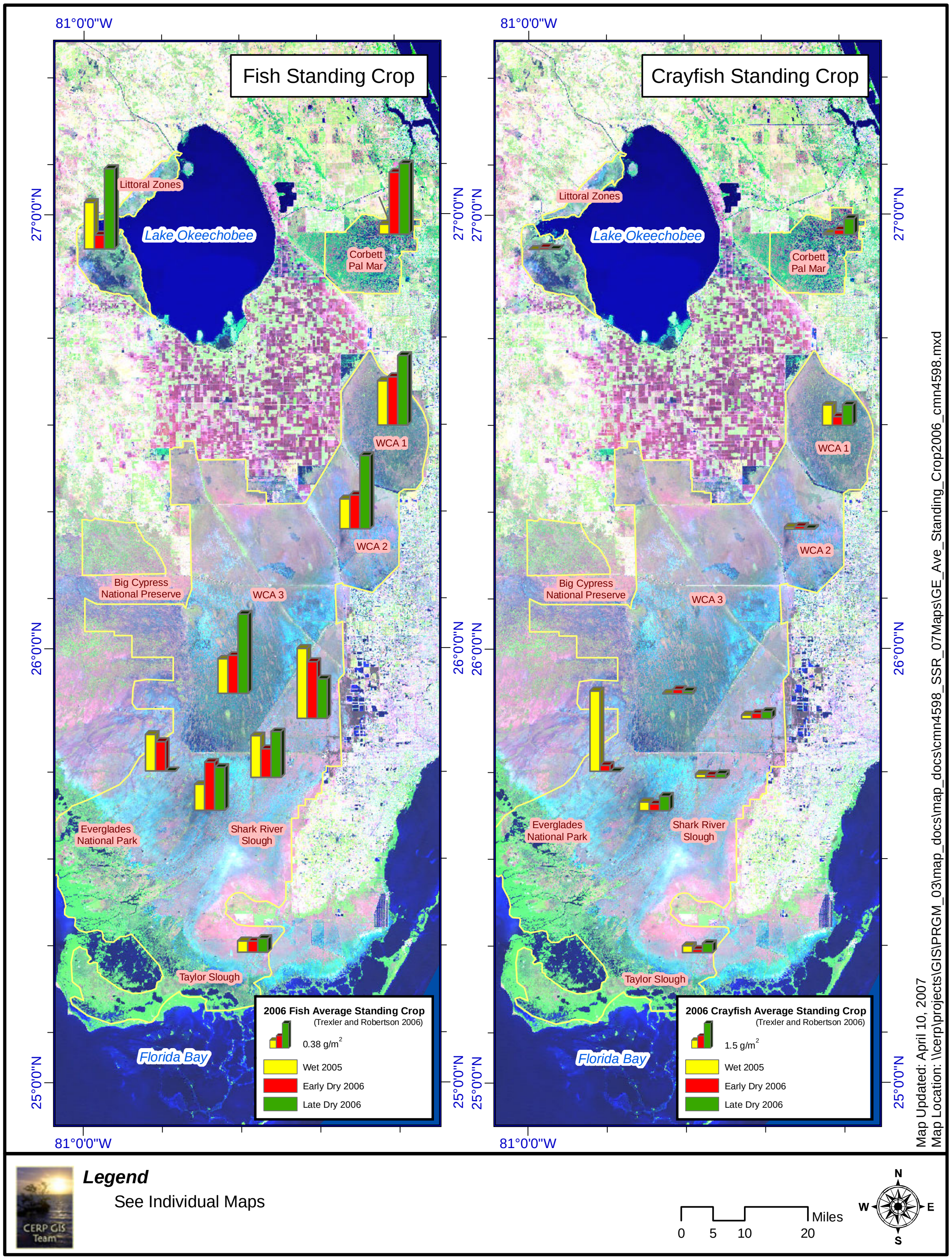

Figure 7B-18. Average standing crop of marsh fishes and crayfish during late 2005 wet season and early and late 2006 dry season.

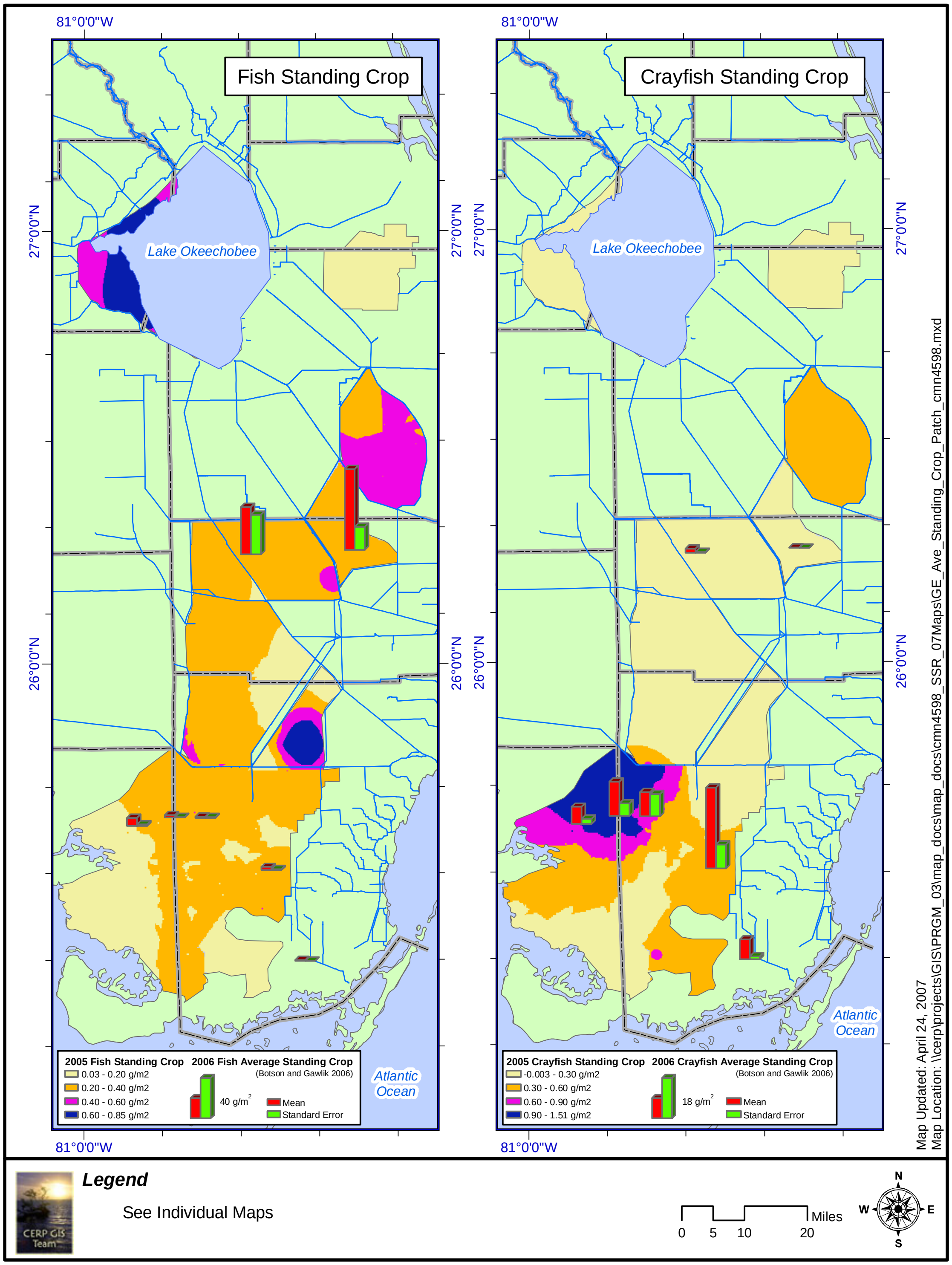

Figure 7B-19. Average standing crop of marsh fishes and crayfish in concentration patches during 2006 dry season plotted over standing crops during 2005 late wet season.

WADING BIRD NESTING IN 2006

The 2006 nesting season represented a successful year for wading birds in terms of overall nest numbers. Total number of wading bird nests in the greater Everglades wetlands during 2006 is estimated to exceed 63,000 excluding cattle egrets and anhingas (**Table 7B-2**). This number includes 39,677 nests in the WCAs, 10,000 nests in the Park, and 13,693 nests in the Lake Okeechobee littoral zone. The strong initiation of nesting in 2006 is characteristic of resurgence in total numbers of nesting birds since 1999.

In addition to the large numbers of nest initiations during 2006, nesting success was unusually high for all wading bird species and few colony abandonments were noted. Inter-colony average probability of a nest fledging at least one young (nesting success) in 2006 was 75 to 80 percent for both large and small herons, with an average number of young fledged per nest of 2.5–3.2. Average nesting success of 54 percent for white ibis from Alley North and Loxahatchee colonies was high for the species. Wood stork nests were initiated in December to January during 2006 in comparison to typical January to February initiation. Average nesting success of wood storks at the Tamiami West colony was 71 percent with an average of 2.6 young fledged per nest.

Table 7B-2. Numbers of wading bird nests in the greater Everglades wetlands during 2006. Total wading bird nests exclude anhinga and cattle egret.

	Water Conservation Areas	Everglades National Park	Lake Okeechobee Littoral Zone	Total
Great Egret	7,497	2,629	2,117	12,243
Snowy Egret	8,258	1,755	3,700	13,713
White Ibis	20,892	4,430	6,980	32,302
Wood Stork	190	1,124	0	1,314
Total Wading Birds	39,677	10,000	13,693	63,370

Although 2006 was a strong nesting year for wading birds throughout the Everglades and nesting in southern colonies was higher than previous years, colony sizes in southern ENP remained low compared to the WCAs and compared to historical conditions. Depressed nesting in southern ENP corresponded to the low fish standing crop in an area of otherwise high productivity (**Figures 7B-20a** and **7B-20b**). A possible explanation for the low initiation of nesting in coastal regions of the Park in 2006, despite water recession rates conducive to prey concentration, is that low wet season fish biomass (**Figure 7B-17**) was insufficient to produce dry season prey concentrations that were adequate to support nesting. High crayfish biomass in western ENP did not appear to support extensive wading bird nesting in the southern Everglades during 2006; only small numbers of all wading bird species nested near the region of high crayfish biomass, and all large colonies of white ibis colonies were located in the WCAs and the Lake Okeechobee littoral zone.

ROSEATE SPOONBILL NESTING IN 2006

The three watersheds used by roseate spoonbills nesting in northeastern Florida Bay indicate a temporal sequence in peak prey availability across the landscape that was conducive to spoonbill nesting success during 2006 (**Figure 7B-21**). **Figure 7B-22** shows spoonbill nesting colony locations and numbers of nests in Florida Bay during 2006. The count of 127 spoonbill nests in the northeast subregion during 2006 was well below the average nesting effort of 211 nests in this region since 1984. However, the estimate of 1.61 chicks produced per nest attempt during 2006 was well above the average of 0.79 since 1984 and was the highest nest productivity recorded in more than a decade. Sixty-three of the nests were successful at fledging one or more chicks during 2006 in comparison to a 3 percent success rate during the previous year. The northwest subregion produced 262 spoonbill nests during 2006 in comparison to an average of 211 nests since 1984. The estimate of 1.33 chicks produced per nest attempt during 2006 was above the average of 1.25 since 1984. The nesting success rate of 61 percent during 2006 was comparable to the success rate of 63 percent in the northeast subregion.

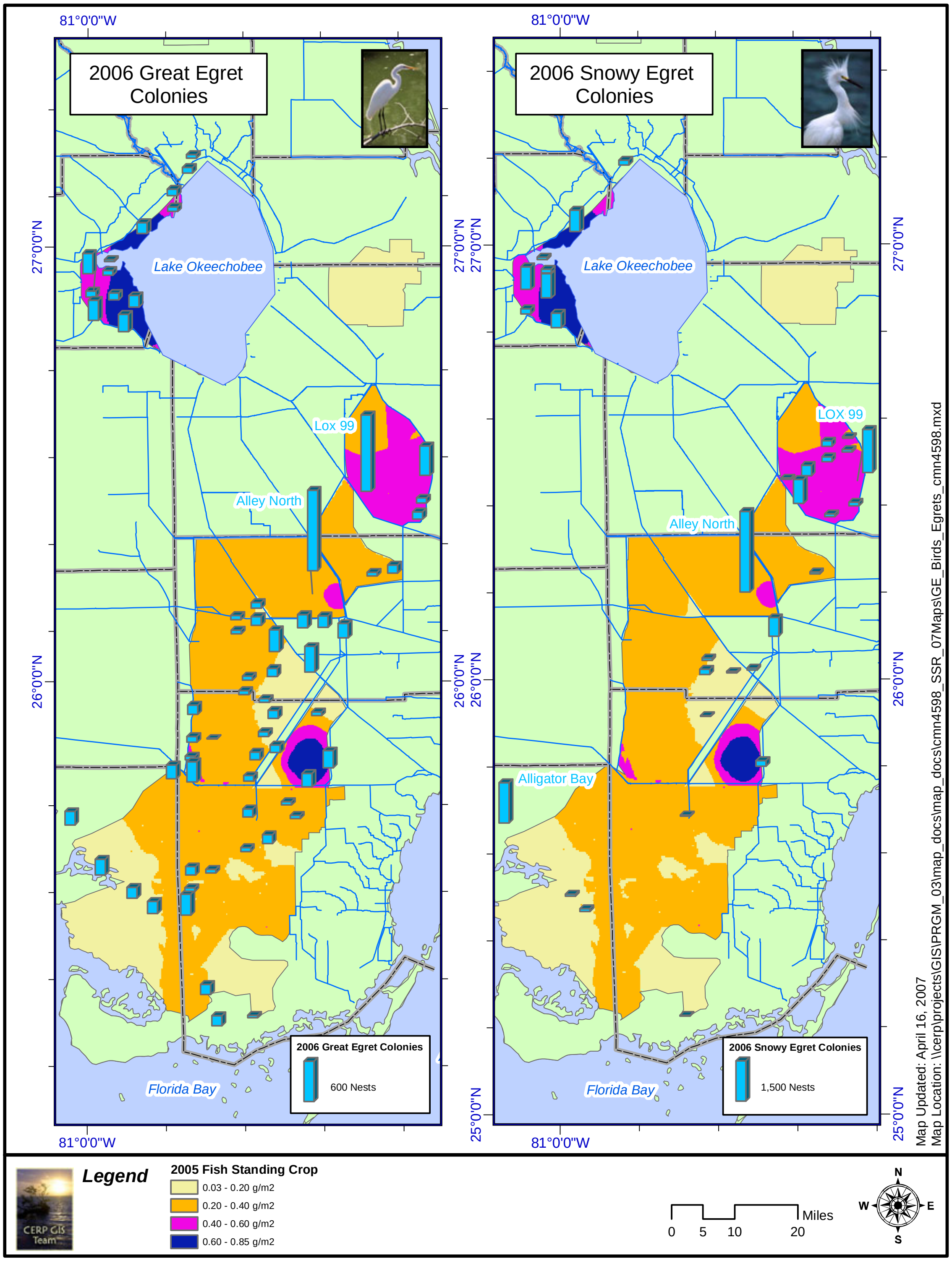

Figure 7B-20a. Wading bird colony locations and numbers of nests in the Everglades during the 2006 nesting season, plotted over fish standing crop during the 2005 late wet season.

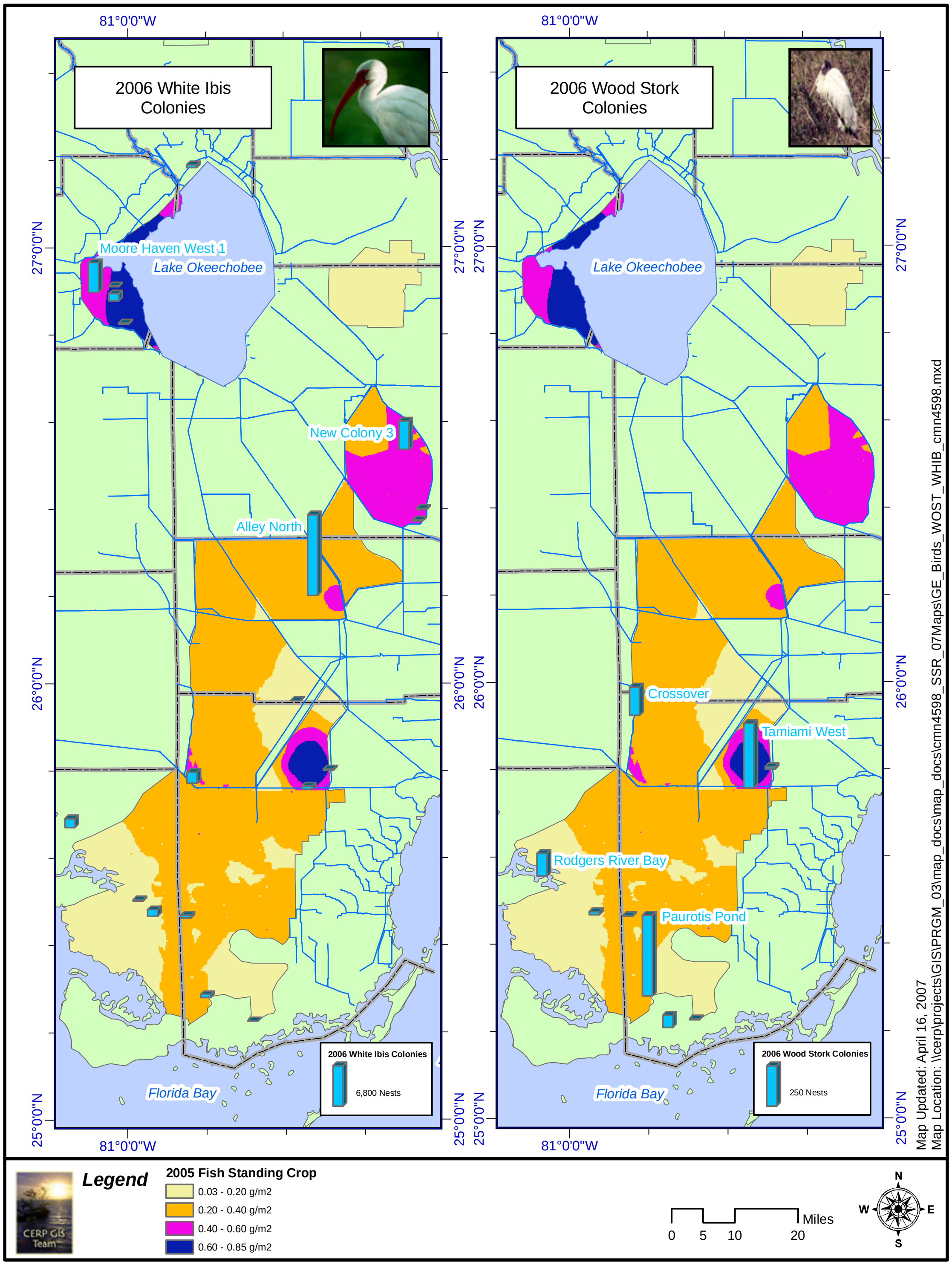

Figure 7B-20b. Wading bird colony locations and numbers of nests in the Everglades during the 2006 nesting season, plotted over fish standing crop during the 2005 late wet season.

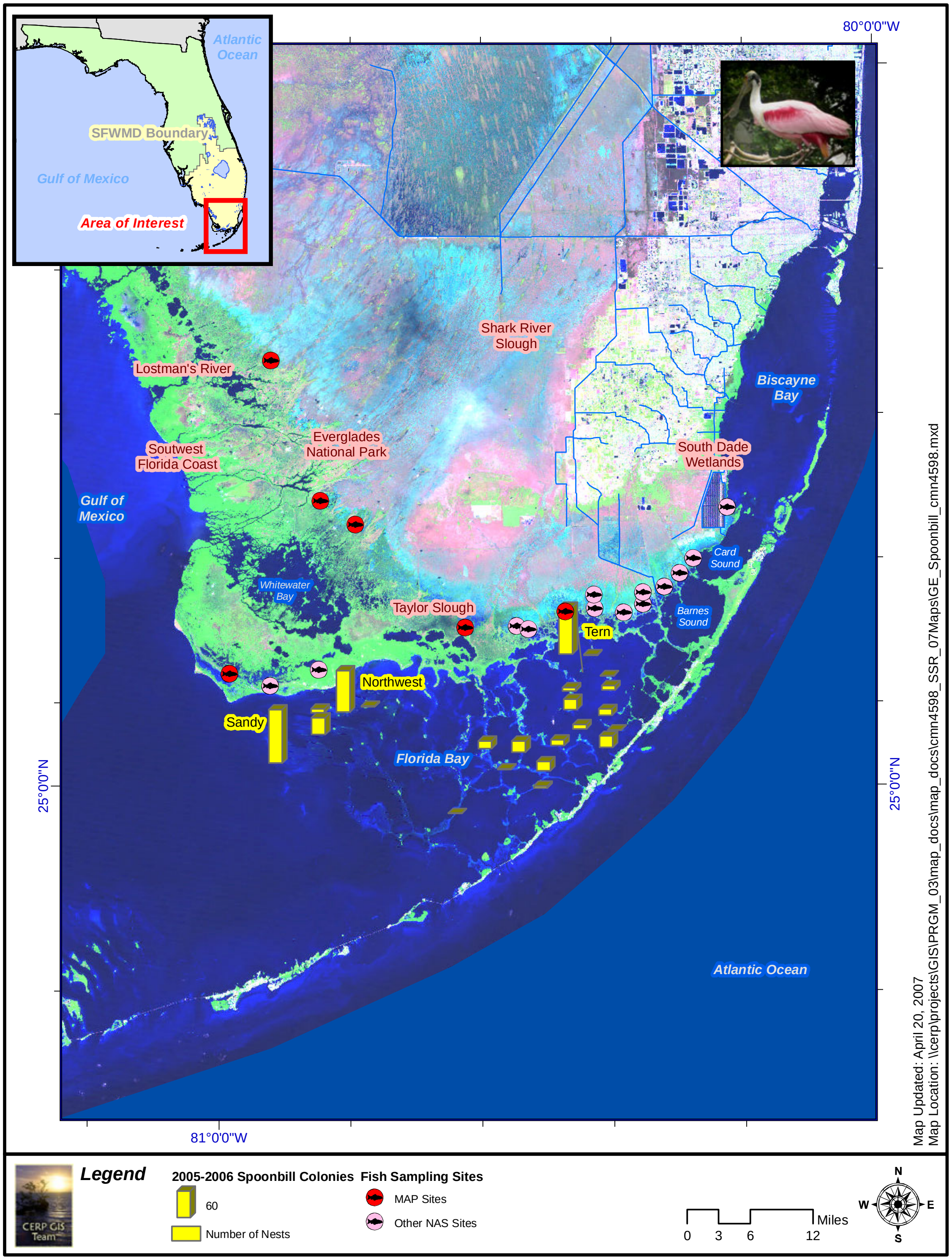

Figure 7B-21. Availability of marsh prey base fishes for roseate spoonbill foraging at drop trap sites in the coastal Everglades during 2005 and 2006.

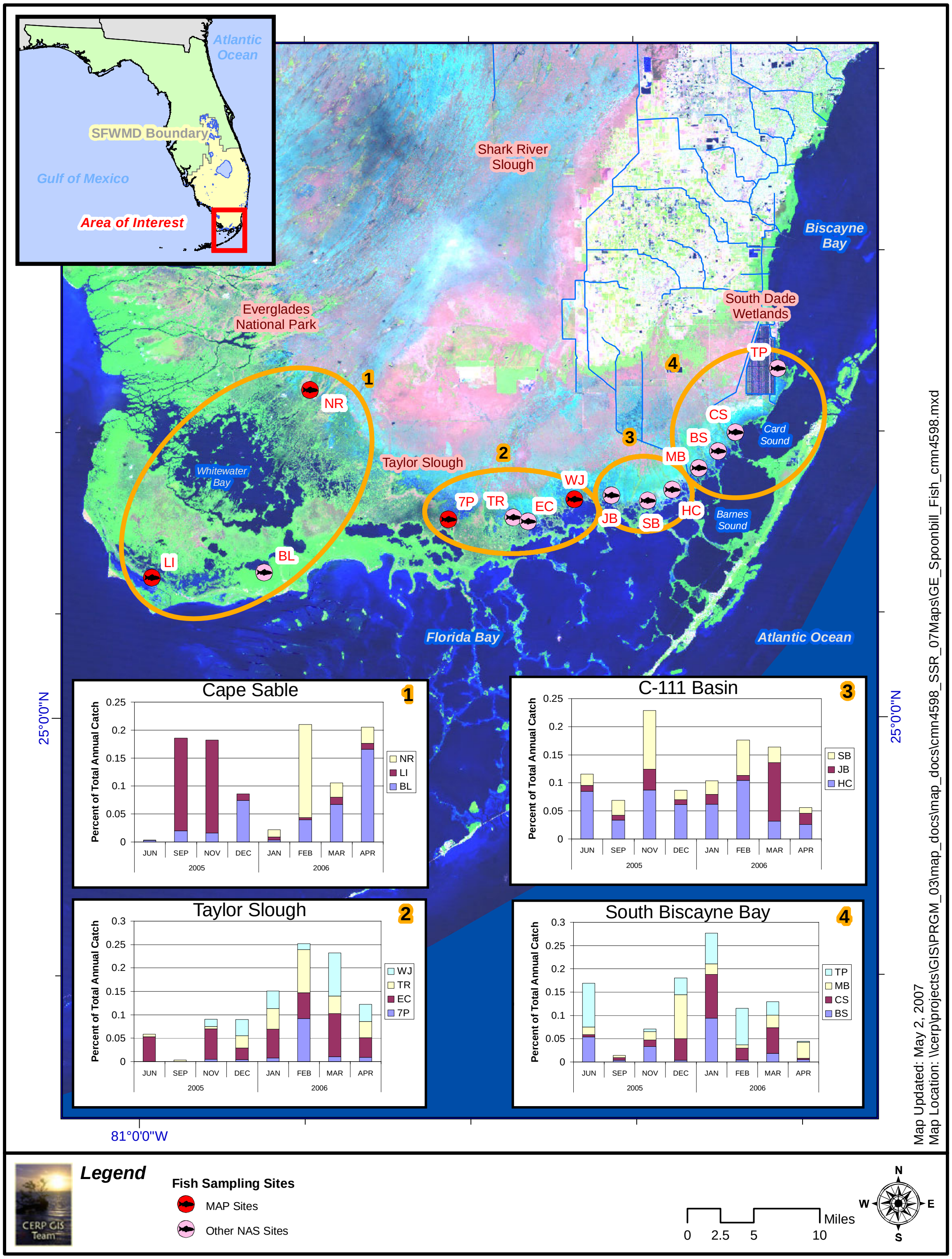

Figure 7B-22. Roseate spoonbill colony locations and numbers of nests in Florida Bay during 2006 nesting season.

SOUTHERN ESTUARIES MODULE

Southern Estuaries expected to be influenced by CERP implementation include Florida Bay, coastal lakes inland from Florida Bay, Biscayne Bay, and estuaries within southwest Florida's mangrove zone from Whitewater Bay to Lostman's River (**Figure 7B-23**). Altered freshwater inflows have affected circulation, water quality, and salinity patterns of the estuaries, in turn altering their structure and function. Changes in SAV habitat structure and distribution have been of particular concern because of their effects on animal populations. CERP implementation is expected to restore more natural salinity regimes to nearshore environments, which, in turn, will have positive consequences for the region's flora, fauna and fisheries. This section focuses on the water quality and SAV hypothesis clusters. The *2007 System Status Report* (RECOVER, 2007) details the progress and results in context of all hypothesis clusters as described in the final draft of the *2006 Assessment Strategy for the Monitoring and Assessment Plan* (RECOVER, 2006a).

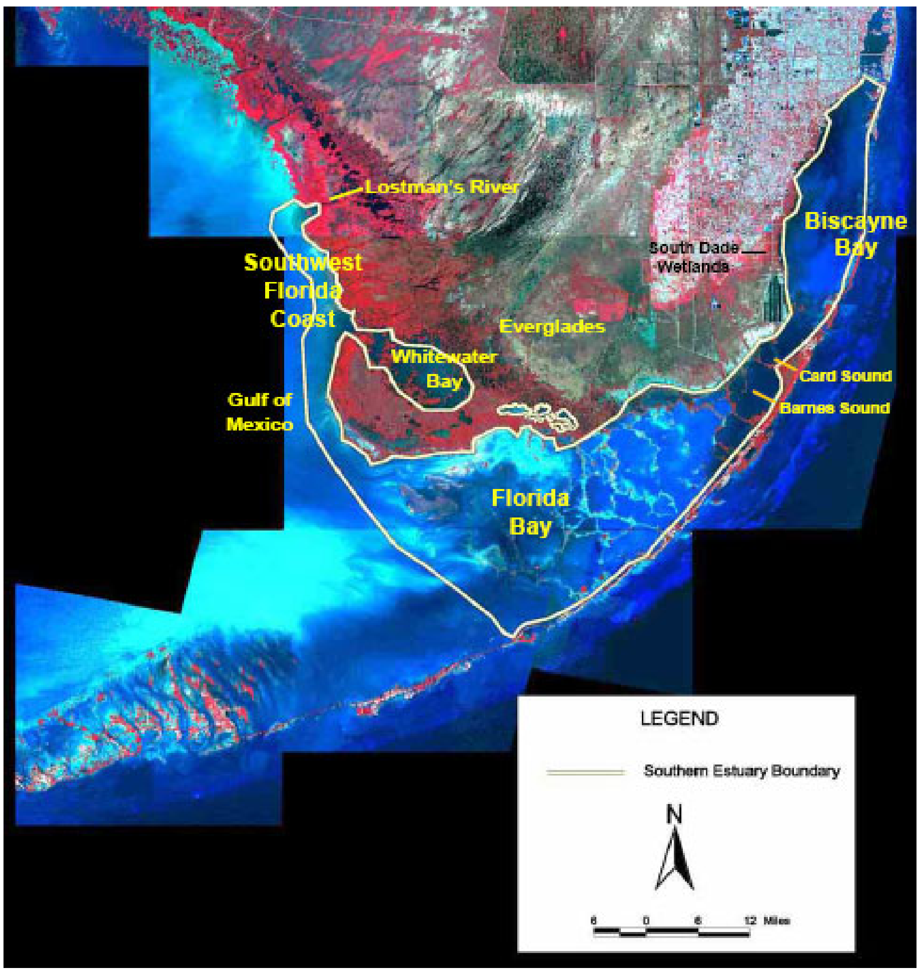

Figure 7B-23. Southern Estuaries boundary.

Water Quality

Water quality monitoring and assessment is based on hypotheses that restoration of more natural quantity, quality, timing, and distribution of fresh water will alter salinity regime and affect dissolved and particulate nutrients delivered to the estuaries, which, in turn, will affect primary production and food, internal nutrient cycling rates and biogeochemical processes, and phytoplankton blooms (RECOVER, 2006a). Salinity and chlorophyll *a* are utilized as indicators to assess water quality status and trends.

CHLOROPHYLL DYNAMICS

Distribution of chlorophyll *a* concentrations was skewed towards lower concentrations in all Southern Estuaries subregions. Distribution of chlorophyll *a* divided between months that typically have high salinities (April–September) and those that have lower salinities (October–March) are presented in **Figure 7B-24**. The highest chlorophyll *a* concentrations were consistently measured along the southwest Florida coast, both in the mangrove transition zone and in the southwest Florida shelf. During low salinity, the area of elevated chlorophyll expands westward onto the shelf, southward towards the Florida Keys, and eastward along the northern edge of Florida Bay. South and northeast Florida Bay, Blackwater Sound, Manatee Bay, Barnes Sound, and Biscayne Bay had consistently lower chlorophyll *a* concentration than north-central and west Florida Bay, the southwest Florida Shelf, and the mangrove transition zone for both high and low salinity periods.

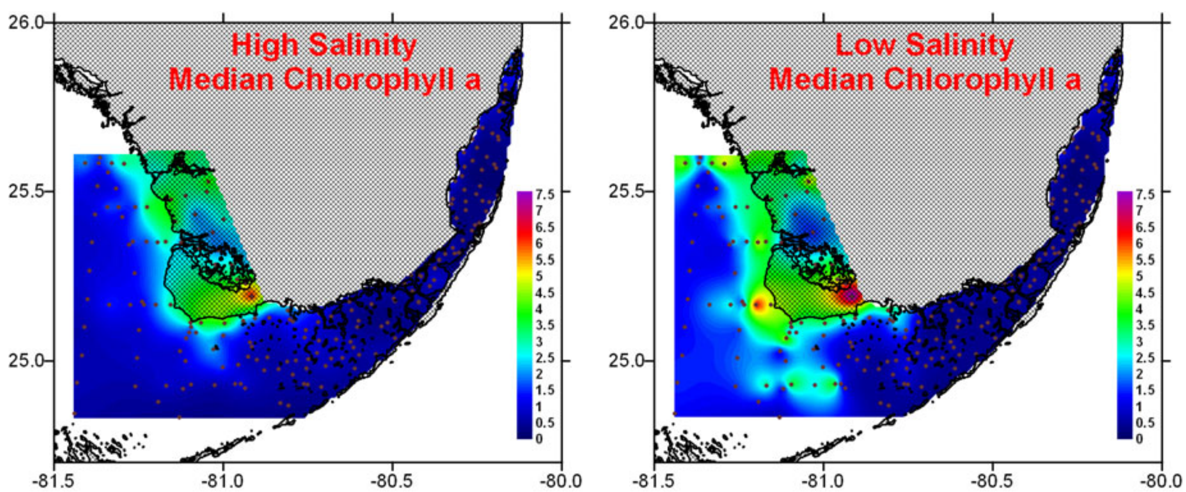

Figure 7B-24. Contour plots of the median chlorophyll *a* distribution in Southern Estuaries during high salinity months (April–September) and low salinity months (October–March).

Figure 7B-25 is a stoplight map displaying chlorophyll *a* and water quality status throughout the Southern Estuaries. The 2006 analysis showed that of the 10 subregions, one was green, eight were yellow, and one was red. The mangrove transition zone, Blackwater Sound, Manatee Bay, and Barnes Sound had the highest median chlorophyll *a* concentrations of any year on record. This increase in algal blooms was not due to CERP but was the result of a combination of hurricanes, water releases, and road construction.

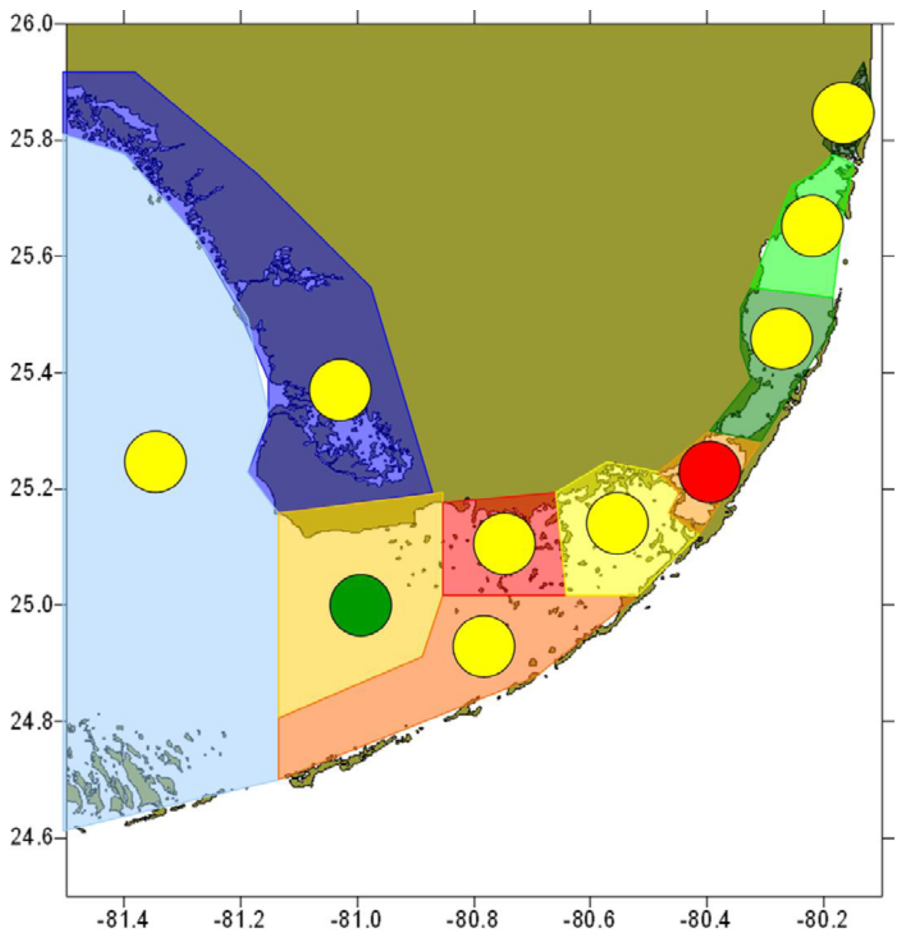

Figure 7B-25. Current status of chlorophyll *a* in the Southern Estuaries.

BISCAYNE BAY SALINITY

Average salinity measured in Biscayne National Park between June 2005 and October 2006 was 26 parts per thousand (ppt), ranging from 11 ppt to 39 ppt. As expected, lower salinities were measured closer to shore, and in particular between canals C-1 and C-103. Sites with highest salinities were located offshore, with salinities approaching oceanic as proximity to the Atlantic Ocean increased (**Figure 7B-26**). Average wet season salinity was 23 ppt, based on average monthly values from June 1 to October 31, 2005. The zone of salinity under 20 ppt extends from the shoreline into nearshore areas south of Mowry Canal and north of Black Point (**Figure 7B-26**). Surprisingly, the lowest salinities were found around Fender Point, which is furthest from any canal outfall, clearly demonstrating the degree to which existing groundwater flow through the porous Biscayne aquifer currently impacts the bay's salinity regime. Although salinity is somewhat higher just south of Black Point, low salinities persist further offshore in this area. Salinity slowly increases with distance offshore and to the north and south. Average dry season salinity from November 1, 2005–May 31, 2006, was 28 ppt, ranging from 36 ppt to 22 ppt. No sites exhibited mean salinity less than 20 ppt during the dry season. Salinity was lowest in the area between Princeton and Military Canals (**Figure 7B-26**). The lowest salinity in both wet and dry seasons was recorded far from any direct canal discharge, which reflects groundwater flow.

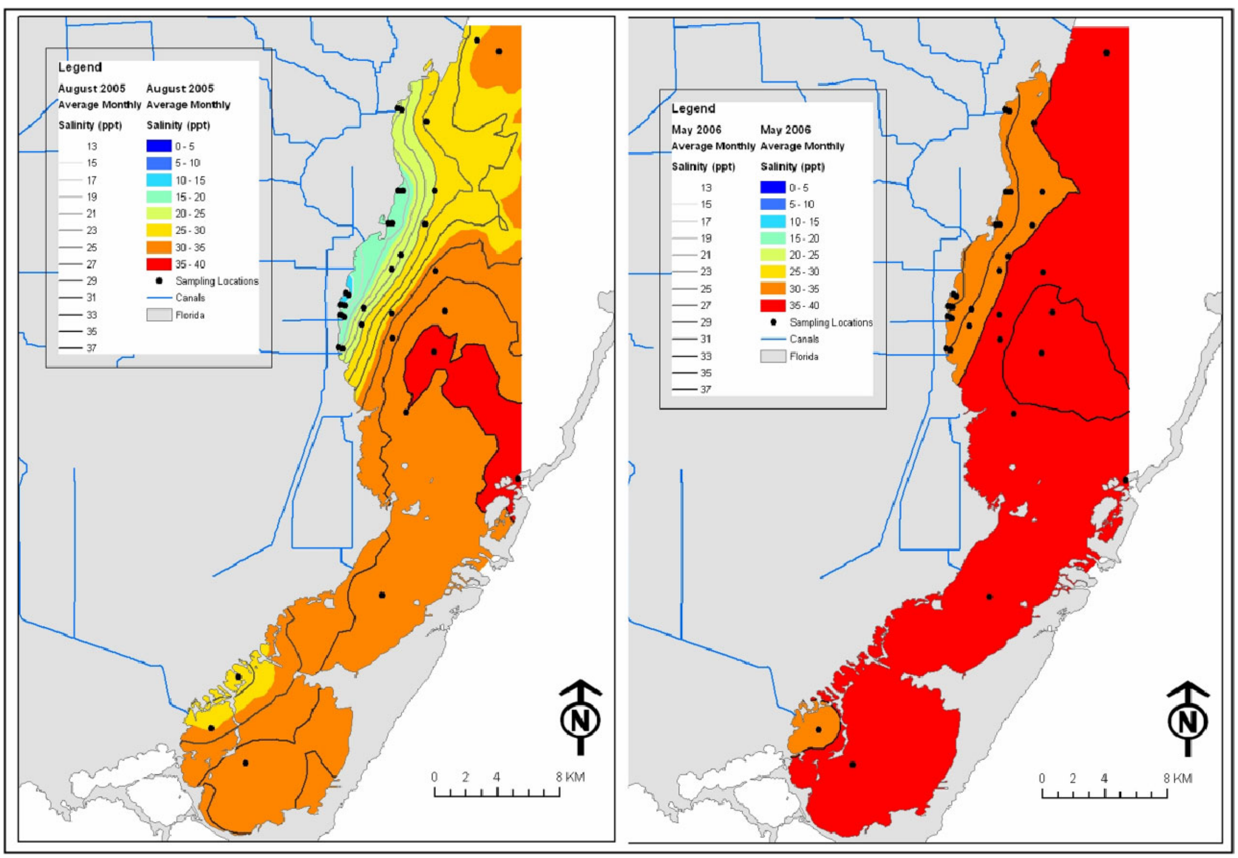

Figure 7B-26. Examples of wet season (left pane, August 2005) and dry season (right pane, May 2006) salinity regimes in Biscayne Bay.

Submerged Aquatic Vegetation

Seagrasses make up the dominant biological communities in the Southern Estuaries that will be affected by CERP implementation. They provide the majority of fisheries habitat in the estuaries. The South Florida Fisheries Habitat Assessment Program is based on the hypotheses that restoration of volume, timing, and spatial distribution of freshwater inflow will alter salinity and water quality, which will affect (1) seagrass cover, biomass, distribution, species composition, and diversity, and (2) change benthic algal cover, biomass, distribution, species composition, and diversity (RECOVER, 2006a). Also, it is hypothesized that significant changes in benthic algae and seagrass distribution can affect susceptibility of sediments to become resuspended and the stability of mud banks as well as nutrient availability to other primary producers. Monitoring is conducted once per year, at the end of the dry season (May–June).

JOHNSON KEY BASIN

In 2006, the Johnson Key Basin SAV community was composed of a variety of taxa, including substantial representation by *Thalassia*, *Halodule* and *Syringodium*, and occasional macroalgal species. Since 1995, *Thalassia* has been increasing in both concentration and occurrence, the relative contribution of *Halodule* peaked approximately five years earlier in 2000 (**Figure 7B-27**). These trends are consistent with increasing light availability (lowered turbidity and water column chlorophyll), increasing salinity, and decreasing water column nutrients (**Figure 7B-28**). Decreases in water column nutrients, turbidity and chlorophyll are also consistent with an overall increase in sediment stability, representing something of a positive feedback loop.

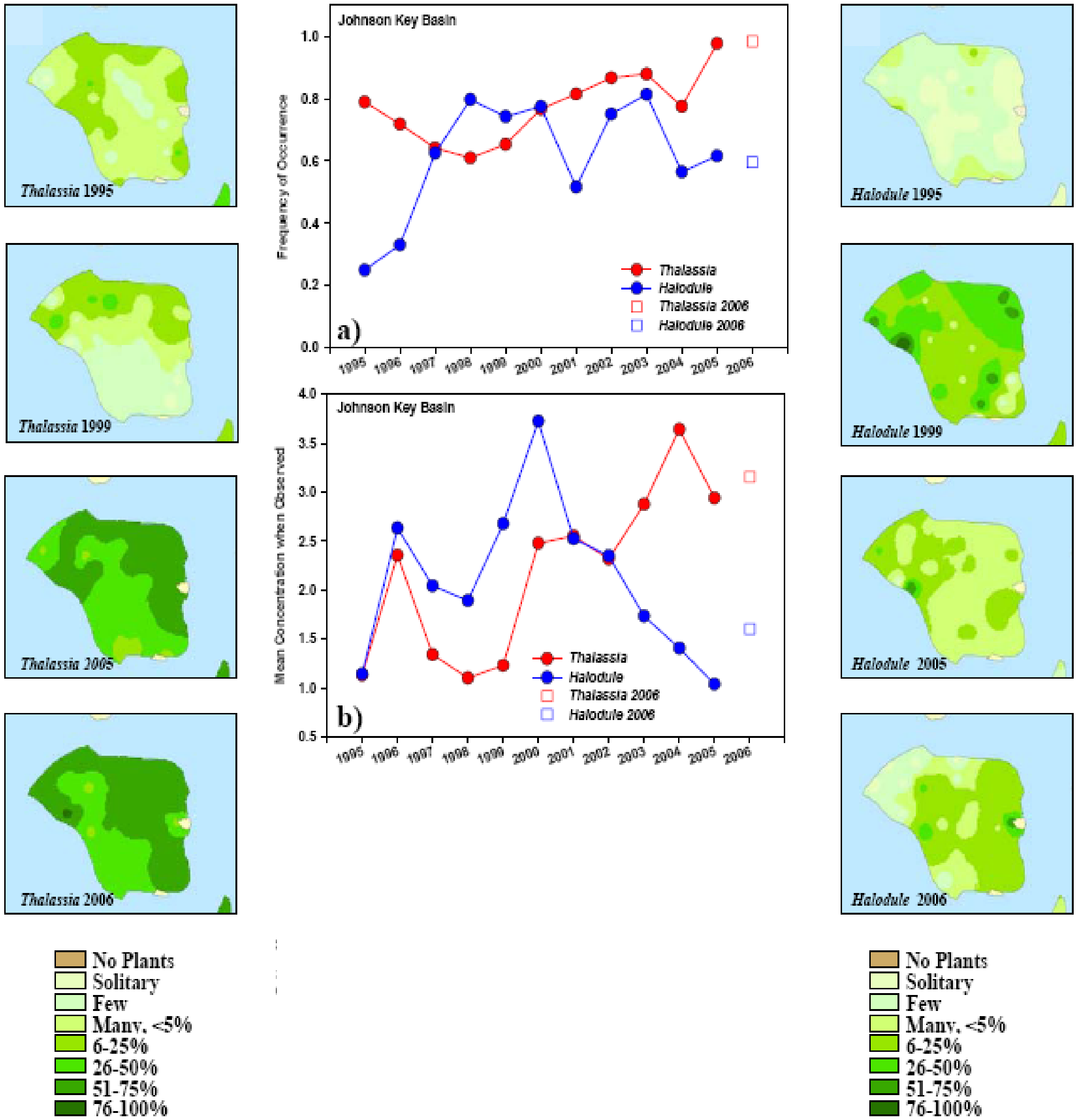

Figure 7B-27. (a) Frequency and (b) concentration for *Thalassia testudinum* and *Halodule wrightii* in Johnson Key Basin from spring 1995 to 2006. Open symbols indicate 2006 values. Contour plots illustrate the distribution and abundance of (c) *Thalassia* and (d) *Halodule* in 1995, 1999, 2005, and 2006 in Johnson Key Basin.

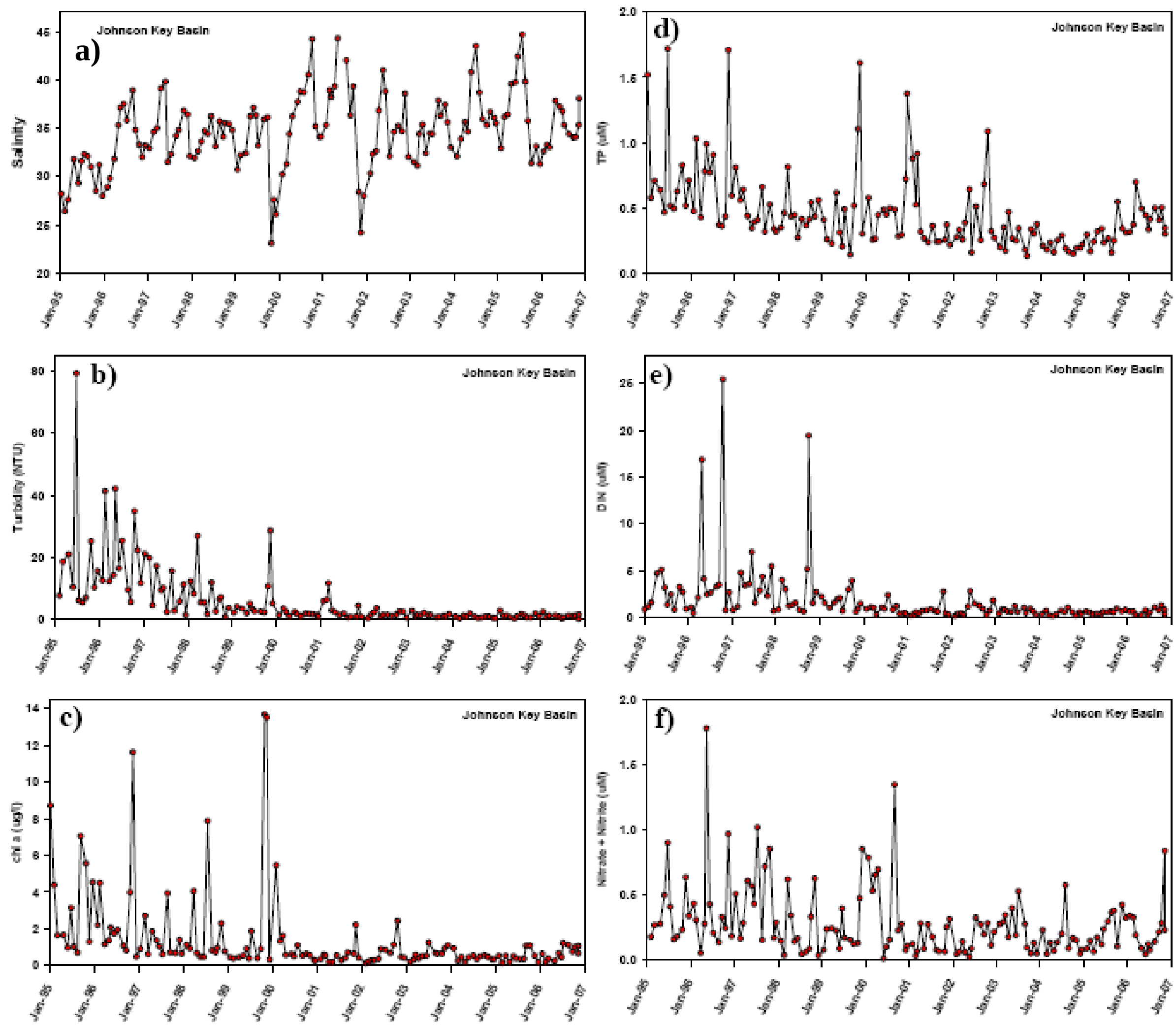

Figure 7B-28. Time-series plots in Johnson Key Basin for (a) salinity, (b) turbidity, (c) chlorophyll *a*, (d) total phosphate, (e) dissolved inorganic nitrogen, and (f) nitrate plus nitrate.

BLACKWATER SOUND

The 2006 Blackwater Sound SAV community was composed of sparse to moderate *Thalassia*, sparse *Halodule*, sparse *Syringodium* communities, and occasional macroalgal taxa (e.g., *Batophora*) (**Figure 7B-29**). Distribution and abundance of all species declined from 2005 to 2006. These declines are consistent with recent decreases in light availability in Blackwater Sound due to substantial increases in both turbidity and chlorophyll *a* levels (**Figure 7B-30**).

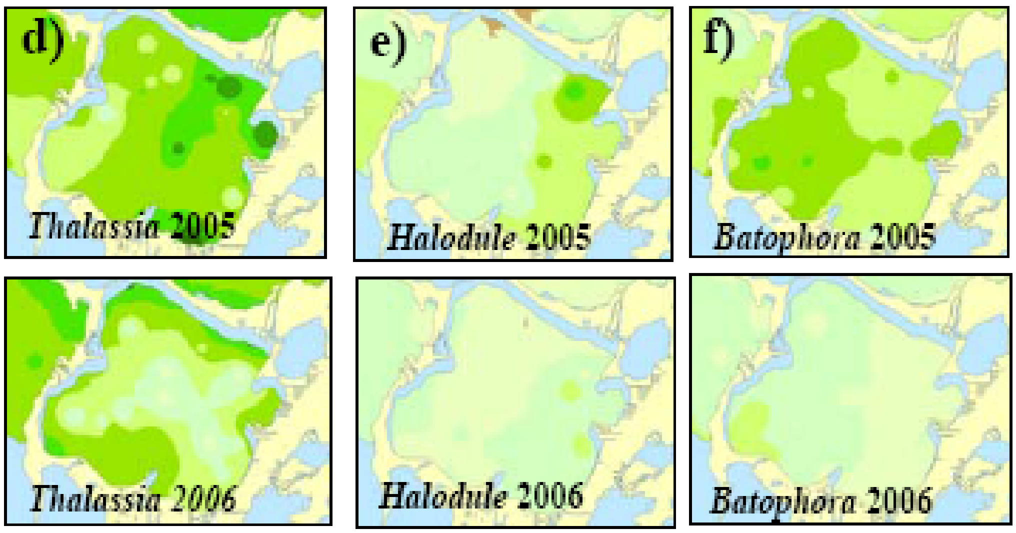

Figure 7B-29. Distribution and abundance of (d) *Thalassia*, (e) *Halodule* and (f) *Batophora* in 2005, and 2006 in Blackwater Sound.

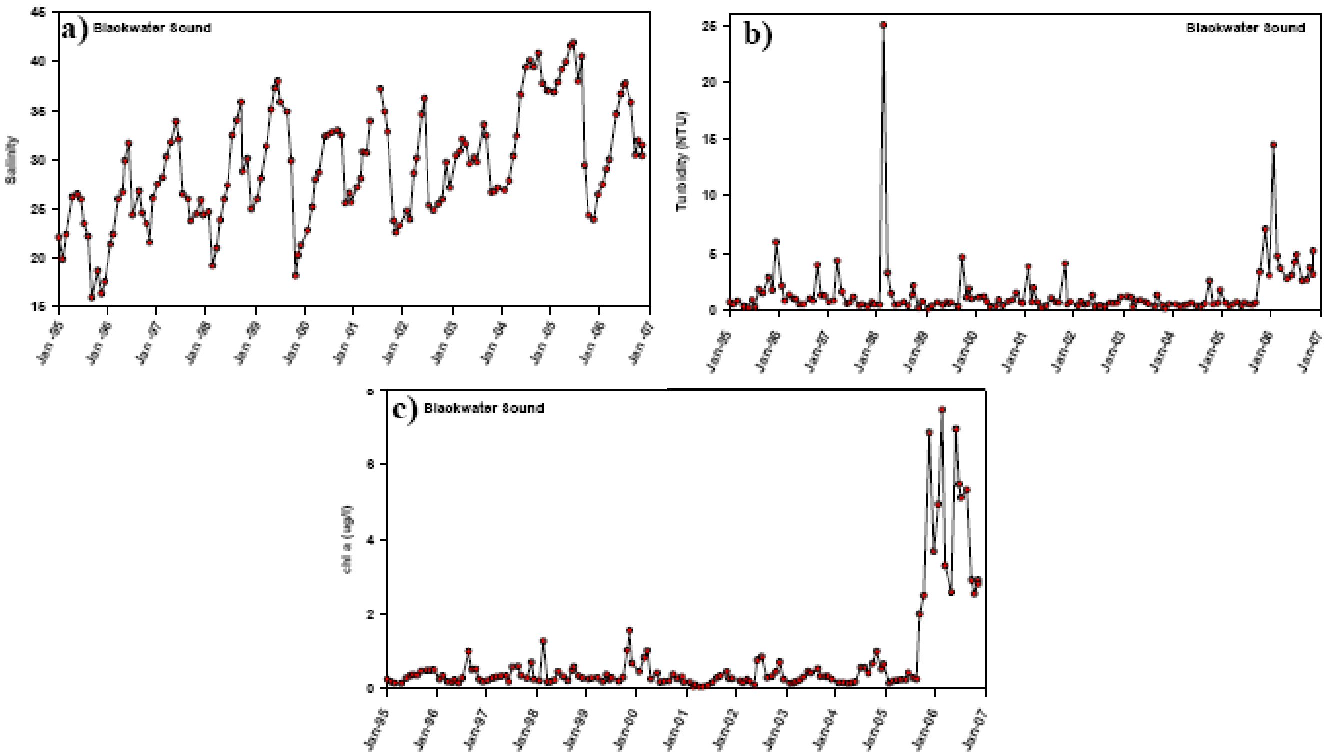

Figure 7B-30. Time-series plots in Blackwater Sound for (a) salinity, (b) turbidity and (c) chlorophyll *a*.

LESSONS LEARNED

The results from the *2007 System Status Report* (RECOVER, 2007) provide the following insights into long-term monitoring and assessment, and their role in adaptive management:

- Multi-decadal restoration programs on the scale of the Everglades and the south Florida ecosystem require dedicated interagency programmatic, scientific and funding support.
- Sustained multi-year monitoring is a pre-requisite for the establishment of pre-CERP conditions and trends. Multi-year monitoring will support hypotheses and interim goals and is an essential first step in the ability to determine changes in the physical, chemical and ecological variables that will result from implementation of CERP projects.
- The MAP has proven to be a scientifically robust and successful strategy for planning, assessing and managing a large-scale restoration program. Lessons learned during management of such a large-scale monitoring and assessment program as well as the interface of this program with adaptive management will be addressed in a revised version of the MAP.
- The *2007 System Status Report* has resulted in refinement of monitoring priorities, a reduction in the number of performance measures and hypotheses being evaluated, and has highlighted the importance of using system-wide performance indicators that support interim goals. Information and lessons learned from the *2007 System Status Report* will be incorporated into future system status reports.
- While the *2007 System Status Report* focused on establishing pre-CERP conditions, future assessments will require forecasting changes based on understanding functional relationships between stressors and ecological effects and to distinguish CERP-impacts from non-CERP influences. RECOVER recognizes that it will generally be impossible to distinguish effects from various projects of the same type in the same subregion or to distinguish restoration effects from other gradual environmental changes on a system-wide level.
- The role of system status reports in the CERP Adaptive Management Program (RECOVER, 2006c) is critical. Results from the system status reports will be used to initiate management actions that are necessary to adjust CERP to meet desired performance expectations. Additionally, new knowledge gained from the system status reports may also be used to update the conceptual ecological models, hypothesis clusters, performance measures, and/or modeling tools. Finally, information derived from the system status reports will be used by MAP module teams to develop triggers, which will be used to initiate an adaptive management response if there are deviations from CERP's expected performance.

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